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THE ENTRANCE TO DURBAN HARBOR, NATAL, has been increased in depth over the bar from 10 ft. 7 ins. in 1888 to 21 ft. 2 ins. at low water. This work has been done under the direction of Mr. C. W. Methven, M. Inst. C. E., and Chief Engineer of the Natal Harbor Works, says the "Natal Advertiser." The increase in depth on this sand bar has been brought about by entrance works designed to concentrate the scour of the tidal waters on the bar, and by the use of sand pump dredgers. The plans of Mr. Methven were endorsed by Sir Charles Hartley and Sir John Wolfe Barry, and they called for pier extensions in the form of jetties to direct the tidal flow, dredging on the bar where necessary, but the reduction of this dredging to a minimum so as to leave the dredgers to work in the inner bay and thus increase the volume of water entering and leaving the inner harbor. Since 1888 Mr. Methven has expended about $3,000,000 on this harbor work, including wharves, quay walls, sheds and appliances for handling cargoes, as well as the outer works on the bar. The two sand dredgers have suction pipes 40 ins. in diameter, and are capable of lifting and carrying to sea from 7,000 to 8,000 tons of sand per day. In 1898-9 879,600 tons were dredged from the bar, but since Nov. 2, 1899, there has been no dredging on the bar itself. Vessels of 23 ft. 5 ins. draft can now enter the harbor at high water. The "Advertiser" regrets to note that Mr. Methven has been sacrificed to the exigencies of local politics, but it hopes, now that the value of his long service is realized, that his claims for recognition may not be overlooked by the Imperial authorities.

THE LAKE ST. CLAIR-LAKE ERIE CANAL PROJECT in which interest is revived, calls for a canal 13½ miles long through low-lying land, with the underlying rock more than 20 ft. below the bottom of the deepest cut. A uniform depth of 21 ft. is proposed, with a canal 156 ft. wide on the surface and 72 ft. wide on the bottom. This canal would enable vessels to avoid the fogs, shoals and rapid current of the Detroit River, and would afford a straight course from the St. Clair flats canal, through Lake St. Clair to Lake Erie. The course would be unimpeded by locks, and a speed of 6 miles per hour could be maintained. The saving in distance by the canal would be 79 miles, between the foot of the St. Clair flats canal and an offing in Lake Erie. In time the saving would be six or seven hours. No estimate of cost is given, but the promoters of the canal claim that there would be a net saving of $1,000,000 per year on the 40,000,000 tons of freight now annually passing through the Detroit River.

THE PROPOSED CANAL from Newtown Creek to Flushing Bay, on Long Island, was planned to be 200 ft. wide and 20 ft. deep, and was to provide a waterway for vessels of moderate draft from the East River to Long Island Sound, without going through Hell Gate. The project has been in the hands of the Board of Public Improvements of New York city and has been strongly advocated by Mr. Henry S. Kearney, Commissioner of Public Buildings, Lighting and Supplies, backed by a majority of the Board. Mr. F. W. Bowley, President of the Borough of Queens, noticed a suspicious activity in real estate along the banks of the proposed canal, and the revival of a franchise in perpetuity for the Newtown & Flushing Canal Co., obtained from the legislature in 1898. Mr. Bowley raised the point that under this charter the canal company might virtually take possession of the canal after the city had built it, and he succeeded in delaying the official adoption of the plan of the canal. He moved that the city condemn and purchase 150 ft. on each side of the canal when built, and on the adoption of this provision, on July 10, he withdrew his opposition. It now appears that the map then approved provides for the purchase of the most expensive land only and neglects to give the city possession of land which might be bought at a low figure; and Mr. Bowley is again protesting to the Board of Public Improvements.

THE PROTECTION OF GALVESTON, TEX., has been submitted by the City Commissioners to a board of engineers for investigation and report. This board is made up of Mr. Alfred Noble, M. Am. Soc. C. E.; Gen. H. M. Roberts, Corps of Engineers, U. S. A., Retired, and Mr. H. C. Ripley, M. Am. Soc. C. E.

MAGNETIC IRON-ORE CONCRETE, for marine construction, is suggested by a writer in "Nature." He points out that if magnetite is substituted for broken stone, and magnetic sand or ilmenite sand for common sea sand in combination with cement, the resultant blocks would weigh twice as much as ordinary concrete, with all the strength of concrete. The increased resistance against wave action would compensate for any additional cost.

THE NINTH INTERNATIONAL CONGRESS of Navigation is to be held at Dusseldorf, Germany, in June, 1902. As delegates to this congress the President appointed on Dec. 6 Lieut.-Col. Charles W. Raymond, Corps of Engineers, U. S. A.; Mr. B. M. Harrod, Past-President American Society of Civil Engineers and Member of the Mississippi River Commission, and Mr. John Bogart, M. Am. Soc. C. E.

A RETURN TO STEAM LOCOMOTIVES is to be made by the Pennsylvania R. R. on a seven-mile branch from Burlington to Mount Holley, N. J., which was equipped with electricity in 1895. The power house supplying current to the line was burned a short time ago, and it is now announced that it will not be rebuilt, but the line will hereafter be operated by steam locomotives.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between a passenger train and the St. Louis fast mail, on the St. Louis, Iron Mountain & Southern Ry., near Malvern, Ark., on Dec. 5. Three persons were killed and over 30 injured in the wreck. The cause of the collision could not be learned.

TIE-RENEWALS AND TIMBER SUPPLY are being taken up for consideration by the Committee on Ties, of the American Railway Engineering and Maintenance of Way Association. An endeavor is being made to institute a uniform style of record, and special blanks in tabular form have been prepared and distributed for the collection of statistics as to (1) tie-renewals, (2) life of ties, (3) treated ties, and (4) a comparison between different kinds of wood. It is pointed out that in course of time the records as to life of ties will be very valuable, and that they can easily be kept in the form suggested. The committee has also decided that in view of the growing scarcity and increasing prices of timber for ties it is desirable to attempt to secure some information as to the probable tie-supply of the country. It is realized that the subject is a difficult one, and that the results will be of problematical value, but there is no doubt as to the desirability of obtaining information on this point, if possible. This investigation, if it is to be of any value, must extend over a number of years, but a commencement has been made by sending out special enquiries as to the following points: (1) Materials used and source of supply; (2) Changes in specifications; (3) Renewals with ties from outside sources (not cut along the line); (4) Supply of tie timber still available on individual lines; (5) Supply of inferior timbers in country tributary to these lines. Copies of the enquiries and of the tabular blanks for tie records may be obtained from the Secretary of the association, Mr. L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

THE YALE SCHOOL OF FORESTRY has divided its senior class into two sections, and has sent one of these sections to a lumber camp in Maine and the other to a similar camp in Pennsylvania. Each section must spend three weeks in studying lumbering methods and each student must report his observations.

THE GRAND RAPIDS WATER CONTRACT SCANDAL has resulted in convicting a former city attorney of bribery. Some months ago a huge contract for a water supply from Lake Michigan was authorized by the city government. Its execution was prevented by the Mayor, who showed that the contractors had made false representations regarding alleged financial backers in New York city. Later the city attorney was charged with having accepted $75,000 for assistance in carrying through the proposed contract. After a long, sensational trial a jury has just declared the man guilty. It is said that an appeal will be taken. Not long ago the city received new bids for a supply, but at latest accounts an award had not been made. It is alleged that these bids are all illegal.

PROPOSED ASPHALT CONTRACTS IN NEW YORK have been temporarily enjoined. It is alleged, as a ground for the injunction, that the specifications were drawn in the interests of the National Asphalt Co., and so as to prevent all competition. According to the New York "Tribune," Mr. De Lancey Nicoll, counsel for the National Asphalt Co., has issued a statement denying in detail that the specifications are in the interests of his company. He says that as the specifications now stand they admit any refined asphalt which possesses "75% of bitumen." A large part of Mr. Nicoll's statement is designed to show that the present specifications are no more designed to throttle competition than those in use under the Strong administration, a proposition that does not necessarily have any bearing upon the contentions of those who sought the injunction.

THE CENTRAL ASPHALT AND REFINING CO. has about completed its plant at Port Neches, not far from Beaumont, Tex. The Vice-President, Mr. W. W. Talbert, of Memphis, says that the capacity of this plant is 3,000 barrels of asphalt per day, using for this output 7,000 barrels of Beaumont oil of 44% asphalt. The so-called G. F. Culmer process will be used, and the product is to be absolutely pure asphalt, which will not melt under 248° F. It is to be especially adapted for paving material. U. S. Senator Chas. A. Towne is the President of the concern and the capital stock is $250,000.

700 TONS OF BASIC IRON IN 24 HOURS is a new world's record for blast-furnace production, made on Nov. 20 by No. 3 furnace of the Carrie Group of the Carnegie Steel Co., at Rankin, Pa. The next best record is 59 tons less than this, made by one of the Duquesne furnaces of the same company. The No. 3 Carrie furnace is one of two planned for a minimum output of 700 tons per day. These furnaces are 100 ft. high, 23 ft. diameter in the bosh and each has 12 tuyeres. On Nov. 20 the furnace was working on non-Bessemer ore ranging from 52 to 58% iron and 0.1 phosphorus. One cast required 10 ladles and yielding 168 tons, and a cast was made every four hours. During the 24 hours the total of 2,270 tons of material charged was made up of 1,450 tons of ore and cinder, 660 tons of coke and 160 tons of limestone. The average cast netted 115 tons, and 1,871 lbs. of coke made one ton of iron, says "The Iron Trade Review."

A TUNNEL CONNECTING NORFOLK AND PORTSmouth, Va., and passing under the Elizabeth River, is being promoted by Mr. H. L. Page, of Norfolk, and a bill looking toward its construction will be placed before the next Virginia Legislature. The estimated cost of the proposed tunnel is about $1,000,000, and it seems to be planned for both a roadway and railway purposes.

THE STRAIT OF CANSO BRIDGE CO. is applying to the Dominion Government for a charter. This company proposes to erect a combined railway and highway suspension bridge across the Strait of Canso, from Port Hastings to Cape Porcupine, and to build connecting lines of railway. No detail of the work is given other than to state that the main span would be "at least" 1,000 ft. and that the estimated cost is $4,000,000.

THE YUKON TELEGRAPH CO. reports that its line is now carried to a point 40 miles north of Dawson City, to Fort Egbert. This line has cost the Canadian government about $500,000; Mr. Charleston had charge of construction for the Canadian government, and General Greeley assisted in the construction of the part passing through American territory.

THE PNEUMATIC DYNAMITE GUN mounted at Hilton Head, S. C., was officially tested on Dec. 8. Eight projectiles loaded with from 50 to 200 lbs. of explosive gelatine were fired on a range of 6,000 yds. Of these six exploded on impact and two fitted with time fuses exploded at such a depth below the surface as not to be noted—if exploded at all. Five dummy projectiles in a speed test were fired in 10½ minutes, instead of 20 minutes, as required by the government, and 40 air shots were successfully made in an endurance test. This gun was made by the Pneumatic Torpedo & Construction Co., of New York.

LEARING AND ENLARGING THE SPOT POND STORAGE RESERVOIR, METROPOLITAN WATER SUPPLY.

By Caleb Mills Saville, M. Am. Soc. C. E.*

When the Metropolitan Water Board of Massachusetts decided to use Spot Pond as a storage and distributing reservoir for the supply of the district north of Boston, it became necessary to do considerable work to bring the basin to the standard of modern sanitary requirements.

The pond had previously been used as a source of water supply by several of the neighboring municipalities, but during the dry seasons extensive shallow areas in the northerly portion had been a great detriment.

Previous to 1899, when this work was begun, the pond when full had a water surface of about 296 acres, which was approximately 154 ft. above low water in Boston Harbor, and its available capacity was estimated as 750,000,000 gallons. Since its improvement the area of the water surface is 309 acres, its elevation above low water 163 ft., and its available capacity about 1,800,000,000 gallons, with a depth of 21 ft. over the top of the inlet conduit.

With a rise of 9 ft. in the elevation of its surface, a gain of 1,050,000,000 gallons has been obtained in its available capacity; and by the thorough cleaning its bottom and shores have received, the pond is now in excellent sanitary condition. The plan of utilizing Spot Pond as a part of the distribution system of the Metropolitan Water-Works, included the abandonment of the greater part of its drainage area, and the use of the pond as a storage and distributing basin only.

The water for the new pond is now pumped from Chestnut Hill reservoir, which is supplied from the new Nashua River source at Clinton, and from the old Sudbury and Cochituate sources of the City of Boston, which the Metropolitan Water Board acquired. Upon the completion of the reservoir in Weston, now planned by the Water and Sewerage Board, and the aqueduct now under construction from the Wachusett reservoir to Weston, it will be possible to deliver water into Spot Pond by gravity.

As Spot Pond is one of the principal features of the Middlesex Fells, the State park north of Boston, great care and considerable expense was devoted to making the new basin harmonize with its natural surroundings. With this in view, Messrs. Olmstead Bros., who are in charge of the landscape work of the Metropolitan Parks, were engaged in an advisory capacity, and so far as possible their recommendations regarding landscape effects were followed.

The improved pond, shown in plan by Fig. 1, is about 1½ miles long and ½-mile wide. It has a shore line of about 4½ miles. While it is not possible to drive close to the water edge the entire distance, it is encircled by a carriage road about 3.7 miles in length, from which most delightful views of the pond and its wooded shores may be had. A view of the northern end of the pond, cleaned and ready to be filled, is shown by Fig. 2.

One of the first things done was to cut the trees from the shore to a point above the new high water line. Some portions were heavily wooded, principally with beech, birch, oak and pine. About 1,000 cords of marketable-sized wood were cut, corded and sold, while the remainder, together with the stumps, roots and brush, was burned. Trees of small size were cut with an axe, while those of larger size were grubbed about their roots, a tackle fastened in the tree top and to the butt of a nearby tree, and then the tree to be removed pulled down by 20 or 30 men at the end of the rope. After clearing off the wood, the shores were stripped of loam and soil containing organic matter, from about 2 ft. above to about 23 ft. below proposed high water. The water in the pond was drawn off as low as possible without pumping, and the work of excavation and filling was done by methods employed on dry land, rather than by dredging and filling under water. In some places, even when exposed by the drawing down of the water, the depth of the mud was such that it was not deemed economical to remove it all. In such places so much was removed as would leave its surface at least 16 ft. below water level, and then it was carefully covered with about 12 ins. of clean gravel or sand. Work of this sort in progress is shown by Fig. 5. The material excavated from the shores and bottom was used in filling, the greater part on the low land at the northerly end of the pond. A considerable quantity was used in raising an existing island near the center of the pond, and in regrading certain portions on the west and southerly shores, to give a more bold and pleasing effect after the water was raised.

Besides the above work, 1½ miles of street were relocated; ten dams or dikes were built to prevent overflowing low or undesirable areas; a drainage system to divert the flow from about 800 acres of watershed that included swampy or inhabited areas, was constructed; and two gate chambers and inlets of considerable size, provided with the most approved apparatus for economically caring for the water supply, were built.

Six of the dams had masonry core walls, reaching to solid rock, while the remaining four, where the rock was at too great a depth to be economically uncovered, were built of selected material excavated from the pond. Of the latter, three had cores built of very fine sand, or, where this was not available, of a coarser sand mixed with mud. Typical sections of the dams are shown by Fig. 4. One of these earth dams has a length of 1,200 ft., and another was about 800 ft. long, with a maximum depth of 27 ft. While most of the work mentioned above was done by contract, one portion, on the southerly and westerly shores, and including two islands, was done by the day. The labor, teams and tools for this work were furnished by a contractor for cost plus 10% for profit. The shores of this section were steep and rocky, and had great quantities of stones and large boulders scattered about, under and around which was a large amount of soil containing organic matter which it was desirable to remove.

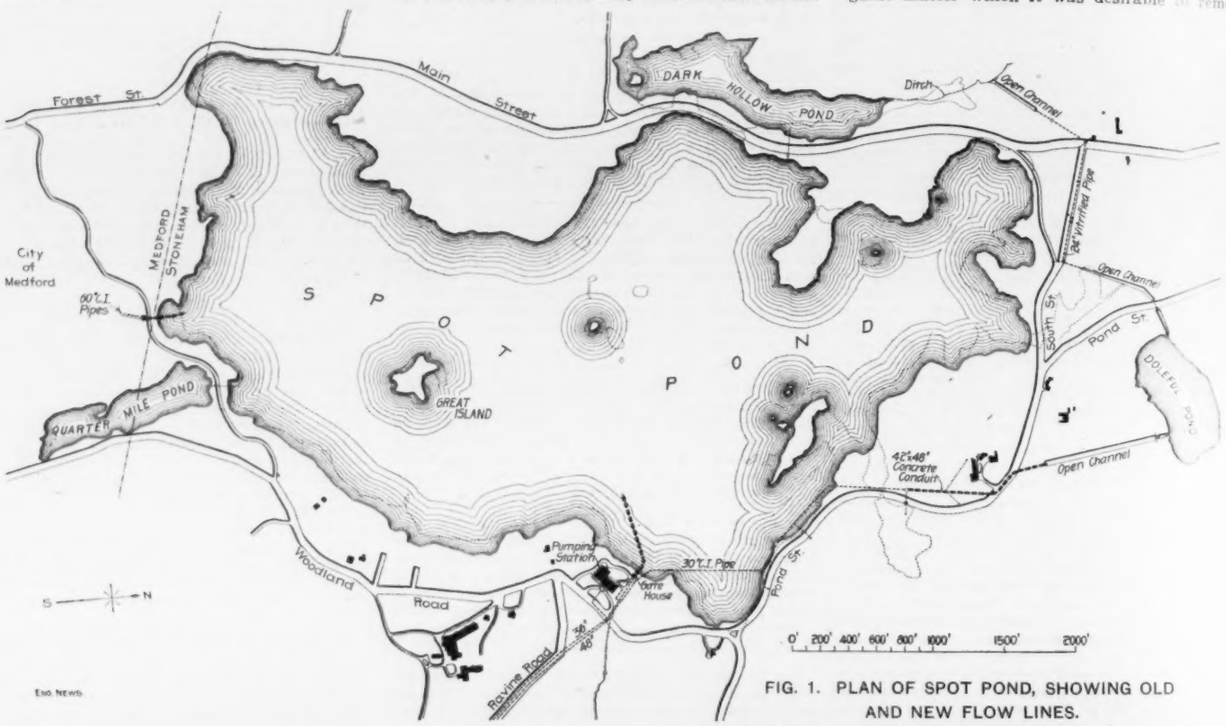


FIG. 1. PLAN OF SPOT POND, SHOWING OLD AND NEW FLOW LINES.

On this account it seemed best to have the work at all stages directly under control of the engineering department. Several bold rock ledges on the shores were carefully cleaned of loam and dirt, but otherwise left in as natural a condition as possible. The remainder of the shore was faced with about 1½ ft. of riprap, after having been stripped of soil. The stone for the riprap was taken from the bottom of the pond and from neighboring stone walls.

The general plan for this protection from wave action was to carry the riprap 2 ft. above, and at least 5 ft. below, proposed water level. Considerable care was exercised in selecting and placing the stone for this work, the landscape architect giving it much attention in the endeavor to make it harmonize with the shore line. In order to break the artificial appearance of the riprapped band, gravel beaches were built at several points. These had a slope of about 1 in 15, and extended out into the pond to a depth of 5 ft. below water level, where they sloped off abruptly and were faced with heavy stone. Another method of breaking this sameness was by building prominent headings from the excavated soil, jutting out into the pond. Some of these were faced on the water side to a depth of 3 ft. with a mixture of gravel and large stones. Others, by a layer of gravel 1 ft. thick, on which was placed 2 ft. of riprap,

*Division Engineer, Distribution Department, Metropolitan Water and Sewerage Board, Boston, Mass.

covered with gravel. In the fill on Great Island, where considerable mud was used, the under gravel layer was 5 or 6 ft. thick. A section of gravel beach, with a riprapped shore beyond, is shown by Fig. 3.

Besides the work on the shores, the islands had to be treated. One of these, known as Great Island, was about 2¼ acres in area, and was covered with forest trees of various kinds, some of which were of considerable size. The southerly portion of this island was comparatively high, with several bold ledge outcrops; the northern portion was low and level and covered with loam and mud. Another island, known as Mud Island, from the amount and depth of the material which covered about two-thirds of it, had an area of about ten acres. This island was formed by the lowering of the water, as was also a third island, of several hundred square yards, near the west shore.

The landscape architects proposed to retain Great Island as a feature of the new water surface. With this in view its higher portion was built up with material excavated from its own low area, and with that brought from Mud Island. About one-third of Mud Island was found to be a gravelly hardpan, which was plowed up and used to cover the portion of the mud area which was too deep to be removed. This hardpan was very compact, four horses on a pavement plow being necessary to start it, and then it was necessary to break it up and knock down the ridges between the furrows by cross plowing. Underlying this hardpan, and also portions of the mud when excavated, was found a stratum of peculiar material. When dry it was very hard and compact, and of a fine silty texture. When wet it was greasy to the touch, firm enough to walk on, but would allow a man to sink readily if standing still. When moist it offered the same resistance to horses and carts, being stiff enough to bear, yet rolling from under the wheels like stiff dough. On these islands, and on the mainland, where the mud was less than 1 ft. in thickness, and easy of access, it was removed. The areas where the mud layer was thin were invariably covered with stones of all sizes from the smallest to those of several cubic yards in size. These stones were thickly packed together, and in order to get at the material to be removed it was necessary to place in piles such stones as one man could easily handle. These stones were later used in the riprapping. So far as possible those portions of the mud to be covered were first drained by ditching. In covering these areas, the gravel was brought as near as possible in carts, dumped, and cast over the mud by shovelers. After a strip was thus covered, a platform of 2-in. 16-ft. plank was laid on the covered area, onto which the teams would drive and dump their load; and thus the process of covering with gravel and plank repeated till the water edge was reached.

In several cases the weight behind would cause portions of the mud area to become detached and pushed out into the water. To prevent this, plank would be laid over the mud and as near the water edge as possible, and men with wheelbarrows sent across, dumping gravel and stone on the outer edge. By this means a dam would be formed which would hold back the inner portion while it was being covered, after which it would remain in place. For the purpose of readily transporting men and teams to and from the islands, two temporary wooden bridges were built. One of these was 170 ft. long, and extended from the west shore to Mud Island; the other was 150 ft. long, from Mud Island to Great Island. These bridges were built of spruce lumber, obtained from a local dealer, and only ordinary labor was employed in their construction, even the carpenters not being first-class mechanics. The substructure was built of 4 × 6-in. timber, sharpened at one end and driven like ordinary piles. These piles were placed in bents of two piles each, those in each bent being placed 6½ ft. c. to c., and the bents spaced 6 ft. apart. Each bent was capped with two 3 × 10-in. girders, fastened to each pile with two ¾ × 13-in. bolts.

On the girders rested four 3 × 8-in. stringers. Those on the outside were spiked to the inner side of the piles, which were sawed off level with the top of the stringer. The other stringers were spaced so as to divide the remaining distance between the others. On the top of the stringers there was placed a flooring of 2-in. × 7-ft. plank. At every fourth plank a ½-in. space was left for drainage, and every 7 ft. a plank, 3 ft. longer than the floor lines, was run out to support a fence. On top of the flooring 4 × 6-in. wheel guards were placed in such position that the ¾-in. drift bolts, 1 ft. long, which fastened them to the bridge, could be driven through the timber and into the pile heads. The detail of the fencing is shown on the sketch, Fig. 6. For diagonal bracing, these timbers were fastened to each pile, before it was driven, with ¾ × 9-in. bolts. These timbers were so placed that after the pile was driven they could be opened out and spiked to the head of the adjacent piles, two being moved lengthwise, but in opposite directions, and one laterally of the bridge.

In order to hold the braces steady while the pile was being driven, it was found most convenient to fasten their upper ends to the pile with 20d. nails. Three nails were used to each brace, driven in until the claw of a hammer could just catch the head of the nail for drawing after the pile was driven.

For driving the pile it was necessary to build a pile driver. As a number of 3 × 14-ft., × 10-in. flat-bottomed boats were at hand, it was decided to use two of them for floating a platform. On this platform was placed the hammer and guide of a rod sounding machine with which it was expected the piles could be driven. The hammer weighed about 60 lbs., and was operated by hand. While towing this pile driver to the work, a stiff

FIG. 2. VIEW OF NORTHERN PORTION OF SPOT POND, CLEANED AND READY TO BE FILLED.

FIG. 3. GRAVELLED BEACH AND RIPRAPPED SHORE OF SPOT POND.

northwest wind caused the water to wash over the sides of the scows, soon filling and sinking them.

This accident showed that a more seaworthy float was necessary, and a 11 × 18-ft. pontoon was built. This was of cribwork construction, made of 4 × 6-in. timbers, spiked together, leaving spaces for 20 empty oil barrels. After the barrels were placed in their compartments, they were securely fastened to prevent rolling, with their bungs up so that any barrel that leaked could be readily pumped out. The framework was floored over with 2-in. plank, well spiked down. On this floor, and overhanging one end of the platform, pile-driving gins were erected, having 20-ft. leaders, braced securely to the deck.

The hammer used in these gins was a block of hard pine, faced with iron, and weighing about 80 lbs. This hammer was worked by hand, three men ordinarily being necessary to run it easily. The only difficulty met with was at a few points where a springy stratum, probably that mentioned above as underlying the mud on the shore, was encountered. In this material the pile would sink under the blow of the hammer; but when the hammer was lifted the pile would come up as though driven on india rubber. In these places it was found necessary to wedge the pile after each blow and before raising the hammer. When the stratum was penetrated, the pile would drive all right until brought up on hard bottom. These bridges were quite firm. As many as six loaded single tip carts were on the bridge at one time. The work for the bridges was completed late in the fall, and as the water was rising gradually, and ice was forming, it was thought the ice would pull the piles and thus easily remove the bridges. This did not happen, however, and in the spring, when they were removed, it was necessary to use a long lever working on the solid portion of the bridge to pull the piles, and even then some of the piles were pulled apart.

In the detailed cost of these bridges given below the labor on the iron work of pile driver and drift bolts is included under the cost of the pile driver. The stock was taken from the scrap heap of the maintenance department. No account is made of tools except those lost. The rope, blocks and lumber were in good condition at the end of the work.

The following figures (Table III.) are taken from a table in the sixth annual report of the Metropolitan Water Board. This table gives the principal items, quantities and cost of the whole work of improvement, exclusive of the engineering; from this it appears that the average cost per 1,000,000 gallons total available capacity is $300.80; and the average cost per 1,000,000 gallons increased available capacity is $515.70.

Mr. Frederic P. Stearns, M. Am. Soc. C. E., is Chief Engineer, and Mr. Dexter Brackett, M. Am. Soc. C. E., is Engineer of the Distribution Department of the Metropolitan Water and Sewerage Board.

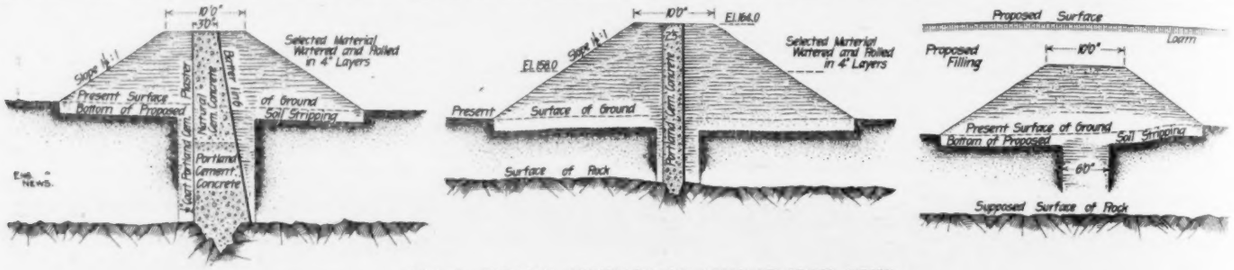


FIG. 4. TYPICAL SECTIONS OF DAMS AT SPOT POND.

TABLE I.—Cost of Bridges.

Pile driver, No. 2: Labor	$38.50	
Double team, 1 day	4.50	
Lumber, 1,200 ft. B.M., at $19	22.00	
Oil barrels, 20 at 75 cts.	15.00	
7-in. 5-roll D. H. blocks, 2 at $1.80	3.60	
⅝-in. manila rope, 178 lbs. at 12 cts.	21.36	
		$105.76
Pile foundation: Labor		83.13
Superstructure: Labor		149.14
Materials:		
Lumber, 21,730 ft. B. M. at $19	$412.87	
Bolts, 207, ¾-in. × 13, and 166, ¾-in. × 9	22.41	
Washers, 60 lbs.	3.00	
Nails and spikes, 5½ kegs	17.33	
Tools (used up and lost)	4.05	
		464.66
Total cost		$802.69
Total length of bridges, lin. ft.		320
Average cost per lin ft.		$2.50
Average cost per M., B.M., lumber, gross		$36.50
Average waste in lumber used		8%
Time employed on work		12 days.
Number of piles driven		108
Waste in piling and bracing		11%
Average cost per lin. ft. of pile driven		$0.22
Average cost per M., B.M., for piling		$55.25
Waste in lumber used in superstructure		5%
Cost of superstructure per M., B. M.		$32.53
Wages paid for labor per day (10 hrs.):		
Carpenters		$2.75 and $2.50
Laborers		$1.75
Cost of abandoned pile driver.		$44.52

TABLE III.—Cost of Spot Pond Improvement.

(1) Cleaning and improving pond, work, boring, soundings and test pits	.....	.....	$5,639
Clearing	80 acres	$101.25	8,100
Cleaning, etc., Spot Pond brook	.....	.....	3,400
Earth excavation	1,036,763 cu. yds.	.29	299,639
Rock ex., msry walls	2,887.8" "	1.45	4,185
Riprap	28,128.6" "	1.13	31,888
Core walls:			
Portland cement	1,951.9" "	7.44	14,513
Natural cement	1,799 " "	5.54	9,961
Dams, plastering	3,636 sq. yds.	.44	1,586
Temporary bridges	.....	.....	847
Weeding, seeding, fertilizing, etc.	.....	.....	5,985
Tree planting.	.....	.....	1,786
Total			$387,528
(2) Drainage system			37,923
(3) Gate chamber and inlets			53,618
(4) Police, advertising and miscellaneous			4,456
(5) Real estate			57,949
Total cost			$541,474

WORKING LOADS FOR MANILA ROPE.*

By C. W. Hunt,† M. Am. Soc. M. E.

The technical reference books in use by engineers do not contain definite information in relation to the proper working loads for manila rope, when used in tackle blocks or for cargo hoisting. The hoisting of heavy weights is an important branch of erecting work, and I desire to record in the proceedings of the Society a statement of the result of an extended experience, together with some examples of the life of rope in actual service, which will be a guide to engineers in judging what service can reasonably be expected in similar cases.

The ultimate strength given in Table II. is materially affected by the age and condition of a rope in active service, and also it is said to be the fact that rope is weaker when it is wet. Trautwine states that a few months of exposed work weakens rope 20 to 50%. The ultimate strength of a new rope given in column II is the result of tests made by the company with which I am connected of full-sized specimens of manila rope, purchased in the open market, and made by three independent rope walks. The results were given in a paper printed in volume xii., page 230, of the Transactions of this Society. Prof. B. Kirsch, of the Imperial Royal Technological Industrial Museum, in Vienna, has since broken over 200 specimens of rope, mostly 35 mm. (1⅜ ins.) and 55 mm. (2⅛ ins.) diameter, and his results agree within 5% with these figures. Professor Kirsch demonstrated that within the limits of commercial sizes of hoisting rope, the full strength could be obtained for larger as well as for smaller sizes. When the strength falls off, the rope is imperfectly laid, or made on a machine too weak for the work. The ultimate strength of rope is, in this class of work, useful for one purpose only; that is, to estimate the factor of safety with any given stress. The strength given is for ordinary commercial rope, which may be greatly exceeded in strength by rope made of selected materials. The table can be depended upon as a reliable and safe guide in estimating the factor of safety for any case in hand.

The proper diameter of pulley-block sheaves for different classes of work, given in columns F, G and H (Table II.) is a compromise of the various factors affecting the case. An increase in the diameter of sheave will materially increase the life of a rope. The advantage, however, is gained by increased difficulty of installation, a clumsiness in handling, and an increase in first cost. It can safely be assumed that the best size is one that balances the advantages and the drawbacks as they are found in practical use, and makes a fair balance between the conflicting elements of the problem. It would be rash for any one to attempt to make a decision from theoretical considérations; but an average of the practice of a large number of users working under all the various circumstances of financial stress or superabundance of urgency or leisure, of mathematical analysis, or rule of thumb decisions, furnishes an acceptable basis for a decision as to the limits of good engineering practice. That average the table aims to give.

An abundance of data is available from which to draw a reasonable conclusion in the premises. A few typical illustrations will make clear the method of procedure, and also be of service in showing what changes in sizes or proportions an engineer, in any given case, could make to reach a higher efficiency of mechanism, or a greater commerical economy. In driving 28,908 piles on

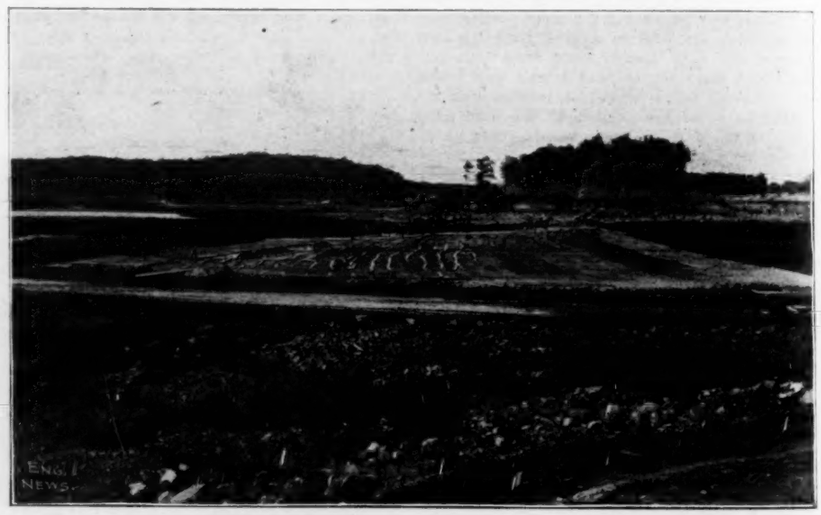


FIG. 5. COVERING DEEP MUD AREAS OF SPOT POND WITH GRAVEL.

*A paper presented at the annual meeting of the American Society of Mechanical Engineers.

†President, the C. W. Hunt Co., 45 Broadway, New York city.

TABLE II.—Cost of Day Work on Section 5, Spot Pond, June to December, 1899.

Quantities.		Cost—Unit.	Cost—Total.	Remarks.
Main Land, Shores.				
Grubbing	5 acres...	$492.23	$2,461	Removing stumps and roots, and grubbing entire area stripped of loam.
Piling and burn'g brush	5 "	100.34	502	Piling and burning stumps, roots and brush.
Earth exca. stripping	39,500 cu. yds.	.55½	21,922	⅓ ± of stripping was loam; ⅔ ± gravel and hardpan; average haul was about 1,000 ft.
Mud covering	3,000 " "	.32	974	Av. depth gravel covering 1.6 ft.; mud very soft—in most cases dam of gravel or rock on water's edge necessary to hold in place; gravel generally cast over the mud.
Mud covering	5,900 sq. yds.	.16½		
Laying riprap	5,430 " "	.37	1,996	Some stone placed by teams, rest by barrows; haul, short.
Facing, fills, etc	2,100 " "	.74	1,548	Faced in two ways—3 ft. gravel and stone mixed; 1 ft. gravel and 2 ft. gravel and stone.
Building road	700 lin. ft..	2.42	1,696	Built with 1 ft. stone and 6 ins. gravel; cost includes fence, catchbasin, rock excavation.
Seeding loam spaces	2.8 acres...	43.38	121	Includes raking and removing stones, roots, etc.
Mud Island.*				
Earth excavation	6,050 cu. yds.	.62	3,752	Material very compact, considerable stone; 300-ft. haul.†
Mud covering	19,555 sq. yds.	.19		Excavated material used in preceding operation.‡
Excav. and refill	1,630 cu. yds.	.71	1,153	Mud less than 1 ft. removed; cost high on account of stone and position of mud.
And haul to Gt. Isld.	2,870 " "	.44	1,259	Includes cost of planking; hauling, about 1,200 ft.
Rock excav. and piling	1,010 " "	.54	544	
Great Island.*				
Grubbing	1.27 acres...	384.32	488	Not as many stumps or roots as on main shore.
Destroying brush	1.27 "	127.15	161	
Earth excavation	11,440 cu. yds.	.54	6,235	Cost includes moving and piling considerable stone.
Laying riprap	1,488 " "	.68	1,018	Large stones on top and bottom had to be handled twice; haul, 800 ft.
Little Mud Island.				
Covering mud	125 cu. yds.	.63	79	The cost includes the cost of stripping a small portion of the island.
Covering mud	667 sq. yds.	.12		
Total cost of work on Section 5			$45,909	

*Items include proportional cost of bridges. †Includes planking. ‡This item includes digging drainage ditches. Labor paid $1.50 and $1.75, latter figure represents 9-10th of all labor. Teams paid $4.50. Lumber cost $19 and $20. Total cost includes 10% paid contractor and total cost of bridges.

the Chicago, Milwaukee & St. Paul Ry., the engineering department kept an accurate account of the number of piles driven by each one of the 79 lines of various sizes of manila rope used. From this record the average number of piles driven by each size of rope was computed, and also the cost of rope per pile driven was ascertained. This account showed that for hammers weighing from 1,800 lbs. to 2,600 lbs., 1½-in. diameter rope was the best, and for hammers from 2,600 to 3,200 lbs., rope 1¾ ins. in diameter should be used. Similar records covering many years have been kept by various coal dealers, of the diameter and cost of their rope per ton of coal hoisted from vessels, using sheaves of from 12 to 16 ins. in diameter. These records show conclusively that, in hoisting a bucket that produces 900 lbs. stress upon the rope, a 1¼-in. diameter rope is too small and a 1¾-in. rope is too large for economy. The size in general use for this work is 1½ ins. The Pennsylvania R. R. Co. use 1½-in. rope, running over 14-in. diameter sheaves for hoisting freight on all their lighters in New York harbor, and handle on a single part of the rope loads up to 3,000 lbs. as a maximum. Greater weights are handled on a 6-part tackle.

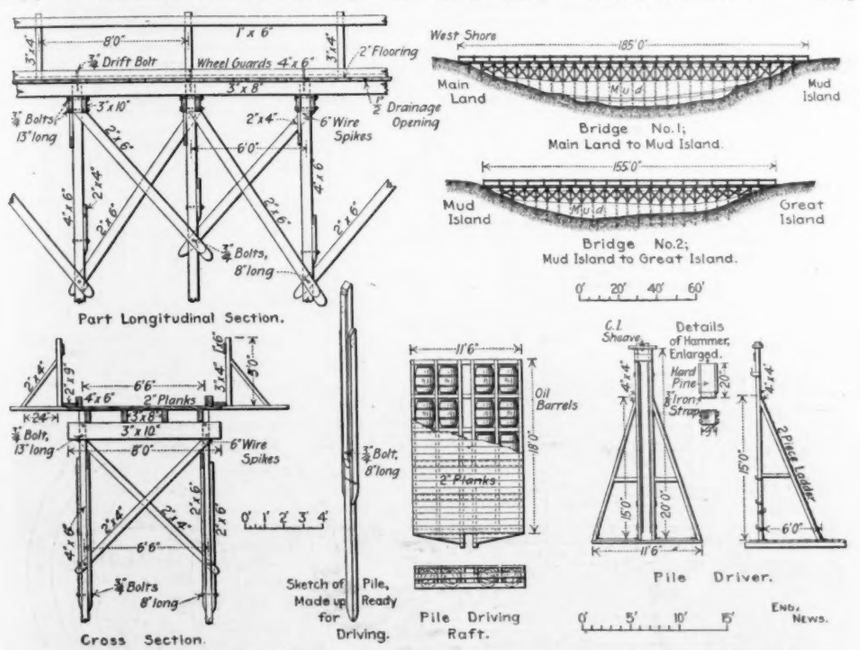


FIG. 6. TEMPORARY BRIDGES USED ON SPOT POND WORK, TOGETHER WITH PILE-DRIVING APPARATUS.

Robert Grimshaw, in 1893, in collaboration with Lieut. J. A. Bell, of the Equipment Bureau, U. S. N., made a series of tests at the Brooklyn Navy Yard on sheaves of various diameters and with various loads. "The rope was ordinary manila, 3 strand, 3⅜ ins. in circumference, such as is used in the United States Navy. It was dry, and tested on a 'cat and fish' tackle constituting a 6-fold purchase; sheaves 8 ins. in diameter, the three upper ones having roller bearings and the three lower ones plain solid bushings. The lower block and hook weighed 75 lbs."

It is interesting to compare the life of a rope when used with the stresses and sheaves given in columns C and F (Table II.) and one used with those of columns D and G. To illustrate this, take two cases using exactly the same size and quality of rope; one to be worn out in hoisting coal from vessels, with stresses and sheaves as per columns D and G, and the other to be used on a rope drive with the stresses and sheaves as per columns C and F; all the wear on the ropes comes from its internal friction in bending over sheaves, and its external chafing in running on and off them. A record of the number of bends made by each of the ropes will be a convenient means of comparison. A rope 1½ ins. in diameter usually hoists from a vessel from 7,000 to 10,000 tons of coal on a well-arranged hoist. The rope will have a working stress of from 850 to 900 lbs. running over three sheaves, one 12 ins. and two 16 ins. in diameter; in hoisting 10,000 tons it makes 20,000 trips, bending in that time from a straight line to the curve of the sheave, or vice versa, 120,000 times. The rope, when this service is completed, is worn out and must be replaced by a new one.

To illustrate the endurance of the rope used in the transmission of power, take a tin-plate mill transmitting 1,000 HP. to the rolls by means of 1½-in. manila ropes. In one particular case the sheaves are 5 ft. and 17 ft. in diameter and 36 ft. apart, c. to c. The rope is 86 ft. long, runs 5,000 ft. per minute, making 13,900 bends per hour, or more bends in 9 hours' service than the other rope made in its entire life. As is well known, the life of a transmission rope is measured by years, not hours. This enormous difference in the life of ropes of the same size and quality is wholly gained by reducing the stresses on the rope and increasing the diameter of the sheaves.

The weakening effect given in the table of various knots, hitches and bends used in rope tackle is based upon experiments made in the laboratory of the Massachusetts Institute of Technology. Forty-five pieces of 2½-in. circumference, three-strand manila rope, cut from one coil, were broken in sets of from three to seven ropes, each rope of a set having the same fastening, and an average of each set computed. Each different set tested some one of the fastenings in common use. The results were not erratic, but consistent, and from them a safe conclusion can be drawn. In examining the various knots broken, it is evident that those fastenings in which the standing part makes a short bend over another part of the rope are the weakest. Those like a round turn and a half-hitch, or a timber hitch, have a less abrupt bend in the standing part, and are materially stronger. With care, an eye in the end of a rope having the ends of the strands tapered down, can be spliced over an iron thimble so that it will have substantially the full strength of the rope, but as it is usually made it is not so strong, for which due allowance is made in the table. The same remarks apply to a splice in a rope. In the table some knots are included that were not tested, but whose approximate strength is evident from their formation. The table is only a guide to be used in estimating the factor of safety. The loss of efficiency by the use of these knots was conclusively settled by the experiments above-mentioned, and the numerical value fixed within such narrow limits that the results cannot safely be ignored in executive work.

It will be understood that a table of working loads must be a general one, covering ordinary cases arising in practice. Local conditions may be such as to make it advisable to vary from the stresses given in the tables. In cases of great importance an engineer should carefully investigate the subject in detail and then decide upon the exact stresses that he will put on his tackle, but ordinary cases are fully covered by the data given in the tables herewith.

In Table II. the work required of the rope is, for convenience, divided into three classes—"rapid," "medium" and "slow," these terms being used in the following sense: "Slow"—Derrick, crane and quarry work; speed from 50 to 100 ft. per minute. "Medium"—Wharf and cargo, hoisting 150 to 300 ft. per minute. "Rapid"—400 to 800 ft. per minute.

The diameter of the rope in column A is obtained by dividing the girth by 3.1416. This method gives for a three-strand rope 0.9, and for a four-strand 0.93 of the diameter of a circumscribed circle. The girth method corresponds closely to the circular diameter of the rope when under stress, and is the most convenient method to use.

TABLE I.—Tests of Efficiency of Six-Fold Tackle.

Net load on tackle, weight raised, lbs.	Theoretical force required to raise the net weight, lbs.	Actual force required, lbs.	Extra power required over the theoretical—lbs.	Extra power required over the theoretical—%
600	100	158	58	58
800	133.3	198	64.3	48
1,000	166.7	243	76	45.8
1,200	200	288	88	44

TABLE II.—Working Loads for Manila Rope.

A. Diameter of rope, ins.	B. Ultimate strength, lbs.	C. Working load in lbs.—Rapid.	D. Medium.	E. Slow.	F. Minimum diameter of sheaves, ins.—Rapid.	G. Medium.	H. Slow.
1	7,100	200	400	1,000	40	12	8
1¼	9,000	250	500	1,250	45	13	9
1¼	11,000	300	600	1,500	50	14	10
1⅜	13,400	380	750	1,900	55	15	11
1½	15,800	450	900	2,200	60	16	12
1⅝	18,800	530	1,100	2,600	65	17	13
1¾	21,800	620	1,250	3,000	70	18	14

TABLE III.—The Efficiency of Knots in a Percentage of the Full Strength of the Rope, and the Factor of Safety when Used with Stresses, as per Column E, Table II.

	Efficiency of the knot.	Factor of safety.
Eye-splice over iron thimble	90	6.3
Short splice in the rope	80	5.6
Timber hitch, round turn, half hitch.	65	4.5
Bowline slip knot, clove hitch	60	4.2
Square knot, weavers' knot, sheet bend	50	3.5
Flemish loop, overhand knot	45	3.1
Rope dry, average 4 tests, same coil.	100	7.0

DEPOSITS OF ASPHALT are reported to exist near Rapid River, Mich. In the fissures in the Trenton rock formation oil is found which has been analyzed as follows by Mr. Frank Ruschaupt, of Milwaukee: Gum asphalt, 46.73%; lubricating oil, 46.55%; moisture, 2.21%; products resulting from distillation, 4.51%. The Michigan Oil & Improvement Co. has been organized to develop these lands, says the Kalamazoo "Telegraph," and a well is being sunk.

ACETYLENE GAS FOR LOCOMOTIVE HEADLIGHTS.

Various systems of car lighting by acetylene gas are now being tried on a number of railways, and some railways are also experimenting with this gas for use in locomotive headlights, in which case the apparatus consists of a generator placed at some convenient point on the engine, while the burner is placed either in the engine headlight already in use or in a separate reflector, as may be desired.

In the system here described, the generating apparatus, Fig. 1, consists of a horizontal cylinder 15 ins. diameter and 36 ins. long, surmounted by an oval upright chamber, 12 × 20 ins., and 30 ins. high. This is placed at the side of the boiler, as shown. Both the horizontal and upright chambers contain water, the upright chamber being connected with the horizontal chamber by means of a pipe leading nearly to the bottom of the latter. On the head of the horizontal chamber are cast two cylinders for containing the troughs of carbide, and this chamber forms the generator proper. In each cylinder is a removable tray, above which is a small trough for spraying water over the contents of the tray. The water is admitted to the spray trough by means of the two vertical pipes shown in the section, Fig. 2, and marked "Inlet Vents to Spray Trough." In the horizontal chamber the space above the water is occupied by the gas, and constitutes a reservoir. As the pressure of the gas diminishes, the water rises in the horizontal trough to the top of the lower inlet vent, admitting water to one of the carbide chambers. As the gas is generated and the pressure increases the water is forced back into the upper chamber until the consumption has again reduced the pressure so that the water can enter the lower vent. This continues until all of the water in the chamber with which the lower vent is connected is consumed; then the water gradually rises to the top of the higher vent and passes into the other chamber, generating gas from the carbide contained in that tray. The pressure of the gas is about 1½ lbs. per sq. in.

The lever shown on the head of the horizontal cylinder can be removed to either one of the five points marked. Placed in a vertical position it means "all off." No water can then enter either of the carbide chambers, and in this position it is left while the chambers are being re-charged. After the chambers are charged, if it is desired to start the generation of gas from carbide chamber No. 1, the lever is placed in position marked "No. 1 On." If, however, it is desired to start the generating from carbide chamber No. 2, the lever is placed in position of "No. 2 On" and the generation of the gas goes on automatically until the carbide is consumed in both of the chambers, this lever being merely for the purpose of starting one or the other chambers first.

The carbide trays are made to contain about 3 lbs. of carbide each, although 1½ lbs. is the ordinary charge. With a ¾-ft. burner in the headlight and two ¼-ft. burners in the cab, the charge in one chamber will furnish gas enough for six hours' consumption. This, of course, can be increased by increasing the amount of carbide in the charge. This headlight is said to be free from the objection of dazzling the eyes of engineers on approaching trains, which has been made to electric headlights, and is also said to light the track ¼-mile ahead of the engine.

The cost of the equipment is $100 per engine, and the cost of operation is said to be about 0.8-ct. per hour for the locomotive headlight and two cab lights. In a test on a locomotive of the Chicago & Northwestern Ry., hauling the Overland Limited train between Chicago and Clinton, with the headlight and cab lights, in seven nights the lights burned 50 hours and 40 minutes with a total consumption of 12½ lbs. of carbide, which cost 4 cts. per lb., making the total cost 50 cts. for seven nights. This system has been in use for two years on the Southern Pacific Ry., and for about six months on the Chicago & Northwestern Ry. It is also in use on the Cincinnati, New Orleans & Texas Pacific Ry., the Chicago, St. Paul, Minneapolis & Omaha Ry., and the Wisconsin & Michigan Ry.

In regard to the experience with this system on the Southern Pacific Ry., we are informed by Mr. H. J. Small, Superintendent of Motive Power, that the road now has about 50 engines equipped with acetylene gas headlights, the first engine having been equipped about two years ago. There has been no trouble experienced with the generators or lamps, and there is no special person in charge of these headlights. They are independent lights, and carbide is applied when required by the various roundhouse inspectors. The cost of equipping an engine is $35, including $19.59 for alteration of the oil headlight, and $15.41 for housing

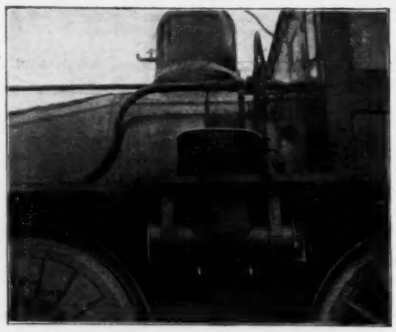


Fig. 1. Acetylene Gas Generator for Locomotive Headlights.

Railroad Supply Co., Chicago, Makers.

reflector and other expense. As to the cost of operation and maintenance, a test of two acetylene gas headlights in service for 43 days each, with the lights burning 230 hours, gave a cost of 1.1 cts. per hour. The cost for coal oil headlight, including wicks, chimney, etc., based on 1,000 miles test, is 1.021 cts. per hour. The cost of attention in the roundhouse, placing carbide instead of oil, is about the same for both systems. The cost of maintenance of electric headlights is 8.373 cts. per hour. This was determined by condensing and weighing the exhaust steam from the motor engine for several hours burning of the

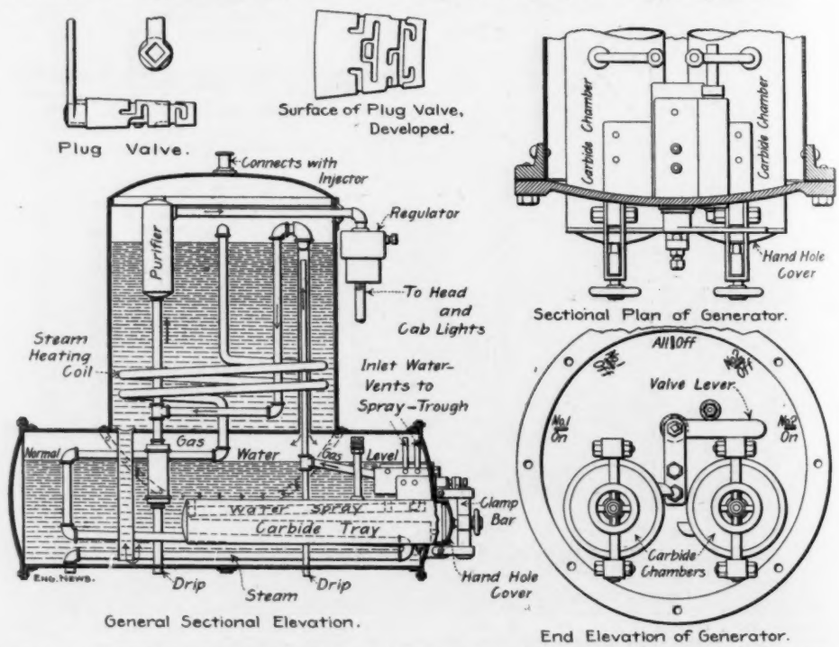


FIG. 2. SECTIONS OF GENERATOR FOR ACETYLENE GAS FOR LOCOMOTIVE HEADLIGHTS.

light: evaporation, 6 lbs. per lb. of coal; steam pressure, 180 lbs. As to the brilliancy of the light, the relative value for equal effect is as follows: electric headlight, 50; acetylene gas, 8; coal oil, 1.

The Chicago & Northwestern Ry. has three engines equipped with this system, which has been in use for about seven months. Mr. R. Quayle, Superintendent of Motive Power and Machinery, informs us that the cost of maintenance is a little more than with oil, and that there has been no trouble with the generator or lamps. The charging is attended to either by the roundhouse foreman or the engineman. He also states as to the brilliancy of the light, that it is much softer than the electric headlight, and not as blinding to engineers of locomotives running towards a locomotive fitted with the acetylene gaslight.

This system of lighting was invented and developed by Mr. E. R. Cook, and the exclusive rights for handling it have been secured by the Railroad Supply Co., Bedford Building, Chicago, Ill.

EXPERIMENTS ON SPIRAL SPRINGS.*

By Chas. H. Benjamin,† M. Am. Soc. M. E., and Roy A. French.‡

The experiments described in the following paper were made under the direction of Mr. French, and the calculations are his. There is such scarcity of reliable data on spiral springs, their strength and elasticity, that it seems desirable to publish the results of these experiments. Our text-books and our technical journals contain discussions and formulas, but very few data from which constants can be obtained to use in the formulas.

In the experiments to be described, an attempt has been made to determine the coefficient of torsional elasticity and the safe stress for different sizes of bar and different ratios of mean diameter of spring to diameter of bar. The following notation will be used:

P = load in pounds.
S = torsional stress in pounds per square inch.
G = coefficient of torsional elasticity.
D = mean diameter of spring in inches.
d = diameter of bar in inches.
H = height of spring in inches.
L = length of bar in inches.
x = deflection in inches with load P.

Then, by the usual formulas for tension and compression springs:

$$P = \frac{S\,d^3}{2.55\,D} \quad \text{and} \quad x = \frac{L\,D\,S}{G\,d}.$$

The springs tested were all made of tempered steel and were open-coil, or compression springs. The results shown in the table were in every case obtained by testing a number of springs made as nearly alike as possible, and using the average loads and deflections for computation. Every spring was first closed solid, coil to coil, several times in a hydraulic press, to remove all permanent set; then placed in a Riehlé testing machine and tested for capacity and corresponding deflection.

To illustrate, take for an example group No. 1 in the table. This group consisted of 15 springs, 9.25 ins. outside diameter and 17.25 ins. free height before closing. The steel used was 1.3125 ins. in diameter and 150 ins. long before the ends were tapered. These springs were placed in the press one at a time, and closed coil to coil twice under the full capacity of the press, 75,000 lbs. The pressure was then removed, and upon measuring they

*A paper presented at the annual meeting of the American Society of Mechanical Engineers.

†Professor of Mechanical Engineering Case Scientific School, Cleveland, O. ‡Pittsburg, Pa.

were found to average 15.25 ins. in height, showing a set of 2 ins. They were then closed twice more, but took no further set. A spring closed solid with 100% overload should take all its permanent set with two closings.

The springs were then placed in the testing machine and the load and total deflection measured. The average load necessary to close them was found to be 10,900 lbs., and the corresponding deflection was 7.0625 ins. When taken from this machine the free height was again measured, but they had taken no more set.

For substitution in the formulas we then have: P = 10,900, d = 1.3125, D = 9.25 — d = 7.9375, x = 7.0625, L = 150.

Substituting and solving for S and G:

S = 97,500 = the torsional stress in pounds per square inch when the spring is closed coil to coil, and G = 12,500,000, the coefficient of elasticity. Dividing the mean diameter of the spring by the diameter of the bar gives a ratio which will be called R, in this case equal to 6.05. Dividing the permanent set by the working deflection gives another ratio, which will be called Y. In this case, Y = 0.285.

In a similar manner were calculated all the results given in the table.

Additional notation used in table:

N = number of springs in group.
O = outside diameter in inches.
H = height before closing in inches.
H′ = free height in inches after producing set.
H″ = height in inches when closed solid.
s = H — H′ = permanent set in inches.
x = H′ — H″ = total action in inches.

The value given for G in most hand-books is 12,000,000. The larger values shown in the tables are doubtless due to the higher grade of steel used. The variation in values of G is probably due to differences in temper, although in some cases the chemical constituents of the steel may have varied slightly. The average value is found to be 14,700,000, which may be written 14,500,000 for convenience.

The proper stress is a more difficult thing to determine. A wide range of stresses was used in the springs experimented with. In each case the stress was that believed to be the best for the conditions under which the spring must work. In some few cases, as in No. 18, it was necessary to use an abnormally high value to meet the conditions. This necessitated a special grade of steel, and great care in manufacture. Such a spring is not safe when subjected to sudden and heavy loads, or to rapid vibrations, as it would soon break under such treatment; if merely subjected to normal stress, it would last for years.

If will be noticed, by comparing columns S, Y and R of the table, that Y varies with both S and R for the same diameter of bar; that is, if R is constant, S and Y increase together, and if S is constant, R and Y increase together. There are some exceptions to this rule noted, but it is believed to be generally correct. This being true, a spring with its mean diameter small, as compared with size of bar, will allow a higher stress with less proportionate set than one of a larger mean diameter. An excessive set means injury to the material, and liability of failure.

Springs of a small diameter may safely be subjected to a higher stress than those of a larger diameter, the size of bar being the same. The safe variation of S with R cannot yet be stated. There is an important limit, however, which should be here mentioned. Springs having too small a diameter as compared with size of bar are subjected to so much internal stress in coiling as to weaken the steel. A spring to give good service should never have R less than 3.

The size of bar has much to do with the safe value of S; the probable explanation is this: A large bar has to be heated to a higher temperature in working it, and in high carbon steel this may cause deterioration; when tempered, the bath does not affect it so uniformly, as may be seen by examining the fracture of a large bar.

The above facts must always be taken into consideration in designing a spring, whatever the grade of steel used. A safe value of S can be determined only by one having an accurate knowledge of the physical characteristics of the steel, the proportions of the spring, and the conditions of use.

For a good grade of steel the following values of S have been found safe under ordinary conditions of service, the value of G being taken as 14,500,000.

For bars below ¾-in. diameter:

R = 3	S = 112,000
R = 8	S = 85,000

For bars 7/16 to ¾-in. in diameter:

R = 3	S = 110,000
R = 8	S = 80,000

For bars from 13/16 to 1¼ ins. in diameter:

R = 3	S = 105,000
R = 8	S = 75,000

For bars over 1¼ ins. in diameter a stress of more than 100,000 should not be used. Where a spring is subjected to sudden shocks a smaller value of S is necessary.

As has been noted, the springs referred to in this paper were all compression springs. Experience has shown that in close coil or extension springs the value of G is the same, but that the safe value of S is only about two-thirds that for a compression spring of the same dimensions.

Table Showing Results of Tests of Spiral Springs.

Group.	Number of Springs.	Outside Diameter	Mean Diameter.	Diameter of Bar	Ratio = D/d	Length of Bar.	Height before Closing.	Height after Closing.	Permanent Set = H — H′	Height when Closed.	Total Action = H′ — H″	Ratio = S/x	Load to Close Spring.	Coefficient of Torsional Elasticity.	Torsional or Shearing Stress.
	N	O	D	d	R	L	H	H′	S	H″	x	Y	P	G	S
1	15	9.25	7.9375	1.3125	6.05	150	17.25	15.25	2	8.8175	6.432	.311	10,900	12,500,000	97,500
2	20	6.625	5.375	1.25	4.3	80	7.125	7	.125	5.9375	1.062	.117	6,375	14,400,000	44,700
3	12	6	4.75	1.25	3.8	67	7.875	7.5	.375	5.875	1.625	.23	16,600	16,150,000	103,000
4	6	5.25	4.125	1.125	3.67	89	10.75	10.125	.625	7.625	2.5	.25	15,800	13,400,000	102,000
5	20	4.75	3.625	1.125	3.22	75	9.875	9.375	.5	7.25	2.125	.235	17,000	12,500,000	110,000
6	40	7.75	6.625	1.125	5.9	100	7.875	7.625	.25	5.5	2.125	.117	4,850	15,800,000	57,500
7	36	5	3.9375	1.0625	3.7	61	7.5	6.9375	.562	5.375	1.567	.36	12,000	14,400,000	100,000
8	64	5.5	4.4375	1.0625	4.18	101	11.125	10.6875	.437	7.625	3.062	.142	12,000	15,100,000	113,000
9	24	4.375	3.3125	1.0625	3.1	48	6.5	6.125	.375	5	1.125	.333	14,800	13,700,000	104,000
10	6	6	5	1	5	84	8.625	8.125	.5	5.625	2.5	.2	8,000	17,100,000	102,000
11	20	4.5	3.5	1	3.5	79	9.875	9.4375	.437	7.25	2.187	.201	12,500	14,100,000	111,800
12	16	4.25	3.25	1	3.25	49	6.5	6.125	.375	4.875	1.25	.3	13,100	13,800,000	109,000
13	36	4.75	3.75	1	3.75	37	4.5	4.125	.375	3.25	.875	.43	12,000	18,100,000	114,400
14	25	4.187	3.25	.9375	3.48	50	6.5	6	.5	4.75	1.25	.40	10,550	14,700,000	106,000
15	800	4.5	3.625	.875	4.15	57	6.375	6	.375	4.4375	1.562	.24	6,250	13,100,000	86,500
16	8	3.75	2.875	.875	3.28	41	5.375	5	.375	4.125	1.875	.43	10,800	18,100,000	118,000
17	24	4	3.125	.875	3.58	60	7.375	7	.375	5.4375	1.562	.24	8,650	13,900,000	103,000
18	40	4	3.125	.875	3.58	51	6.5	6	.5	4.625	1.375	.364	12,000	18,900,000	143,000
19	24	3.875	2.685	.75	3.5	62	7.95	7	.25	5.655	1.345	.186	5,350	13,500,000	83,500
20	8	5.75	5	.75	6.67	172	17.625	16	1.625	8.4375	7.562	.215	2,850	13,100,000	86,500
21	8	4.5	3.75	.75	5	84	8.5	8	.5	5.5	2.5	.20	4,000	15,200,000	91,000
22	12	3.5	2.75	.75	3.67	53	6.875	6	.375	4.625	1.375	.273	6,350	16,900,000	115,000
23	4	4	3.25	.75	4.33	44.5	5.75	4.6875	1.0625	3.0625	1.625	.655	6,500	15,400,000	127,000
24	94	3.5	2.875	.625	4.6	68	7.375	7	.375	4.6875	2.312	.162	3,250	13,600,000	97,500
25	100	3.25	2.625	.625	4.2	37.5	4.375	4	.375	2.8125	1.187	.316	4,325	15,500,000	116,500
26	100	3.25	2.625	.625	4.2	43	4.75	4.5625	.187	3.375	1.187	.158	4,000	16,700,000	109,500
27	200	3.5	3	.5	6	108	9.75	9.625	.125	5.8125	3.812	.032	1,250	13,900,000	76,500

THE GENERATION AND TRANSMISSION OF ELECTRICAL ENERGY BY THE SAN ILDEFONSO CO., MEXICO.

This company has installed two hydro-electric plants which transmit about 3,600 E. HP. to the City of Mexico, situated about 15½ miles distant. These plants are situated on the Rivers Monte-Alto and Tlalnepantla, lying in the western part of the valley of Mexico; and the necessary concession for utilizing this hydraulic energy was obtained from the Mexican government, in 1896, by Mr. Ernest Pugibet, who organized for this purpose the San Ildefonso Co. The hydraulic work was carried out by Mr. de Quevedo.

As described in "Le Genie Civil," for Oct. 12, a fall of 60 m., or 196.8 ft., on the Rio Monte-Alto was utilized to generate electricity through two groups of generators of 340 HP. This electric energy is transmitted to the linen factory of San Ildefonso, 3.1 miles distant. Each of these groups include a Pelton water wheel coupled to a triphase alternator of 250 kilo-watts and 3,300 volts. The transmission line is 2.48 miles long, and is made of three wires, each 4.8 mm. in diameter.

On this same Rio Monte-Alto are two other falls of 393 and 492 ft., respectively; and on the Tlalnepantla there are three falls of 557, 295 and 197 ft. The total of these furnishes a power of 3,600 HP. upon the axles of the turbines; and the course of these rivers have been improved by canals and the water stored by dams of masonry laid in Portland cement. The Rio Monte-Alto, in its upper part, has a flow of 1,000 liters per second, and the canal conveying this flow is about 7½ miles long, terminating in a fall of 492 ft. The second canal, which conveys a fall of 394 ft. to the Fernandez Leal factories, has a flow of 1,200 liters per second, and is 5 miles long. These canals follow the natural contours, and are generally excavated in the native "tepetate," or volcanic tufa of this region. This is hard enough to admit of several tunnels being dug on the line; but much masonry work was required in crossing the numerous ravines and streams. At one point a siphon was necessary, made of steel pipe 23 ins. diameter; this siphon was 754 ft. long, and crossed a valley 187 ft. deep.

The force-mains are steel pipe, connected by bridles and rubber rings. The total length of these conduits is 7,544 ft., and the diameter varies from 3.93 to 3.28 ft. For a full charge the velocity of the water is figured at 1 m. per second. For the plants utilizing the falls of 492 and 394 ft. the generating plants each include five groups of generators of 225 kilo-watts. The turbines were made by Piccard & Pictet, of Geneva, and they make 430 revolutions per minute. Each of these is directly coupled to its corresponding alternator, all of the latter being made by the Westinghouse Electrical & Manufacturing Co., of Pittsburg, Pa. In each plant are two exciters of 22.5 kilo-watts, with 125 volts, each operated by a Pelton wheel. The high-tension apparatus includes six Scott transformers of 225 kilo-watts, transforming the bi-phase current with 440 volts, to a tri-phase current of 22,000 volts.

The works for utilizing the power of the Rio Tlalnepantla include three canals with a total length of 15½ miles, carrying a flow of from 800 to 1,000 liters per second. These canals supply three generating plants, similar in equipment to those on the Rio Monte-Alto.

The transmitting lines are as follows: Villada to Fernandez Leal, 5 miles, six copper wires of 4.8 mm. diameter; Fernandez Leal to Madui, 6.7 miles, six wires of 4.8 mm.; La Alameda to Chilucca, 3.7 miles, six wires of 4.8 mm.; Chiluca to Madui, 2.5 miles, six wires of 4.8 mm.; Madui to Mexico 10 miles, six wires of 6.3 mm. diameter. Two lines with three wires, at Madui, connect the works on the Rio Monte-Alto with those of the Rio Tlalnepantla; and these lines are supported on steel posts made in three sections of differing diameters, and having a total height of 28 ft. In all the cases mentioned the copper wires are coated with a weather-proofing compound which keeps them free from the effects of humidity.

The receiving plant for the City of Mexico is located just west of that city, and here the voltage of about 20,000 volts is transformed into a primary tri-phase distribution of 2,600 volts. Connected with this plant is another for distribution, as the primary distribution tension of 2,600 volts is not too high for a city like Mexico, which occupies a large area compared to its population. The current is distributed by overhead lines in the suburban sections, and by underground cables in the central part of the city; the first type covering 11.16 miles, and the underground lines aggregating 31 miles. The original article enters into all the details of these lines, the arrangement of feeders, the method of working the system and the capacity and operation of the various machines forming the general plant.

The tariff for the sale of electric power varies with the quantity supplied and the duration of the supply. The average charge for electric lighting is 15 cts. per kilo-watt-hour. For power the charge is 1.5 to 4 cts. per kilo-watt-hour. When it is considered that a ton of coal in the City of Mexica costs $9 to $10, these charges are moderate. A number of motors are already operated by this company, some of these motors being of 75 HP.; and the demand is such that—in 1902—the company will probably augment its generation of energy by the erection of storage reservoirs, or by an increase in its steam generating plant.

THEY HAVE TOUGH WHISKEY OUT WEST.—One day last week fire was discovered in a box car near the middle of a Denver & Rio Grande freight train, while passing through Colorado Springs, and just after it had been cut out of the train a tremendous explosion wrecked the car, destroying all the contents except three barrels of whiskey. The car was loaded principally with merchandise, and four kegs of dynamite.—Railway Review.

THE ROCKFORD & BELVIDERE ELECTRIC RAILway, from Rockford east to Belvidere, Ill., 13¼ miles, has been opened for traffic, but the line will not be fully completed and ballasted for some time yet. The road parallels the Chicago & Northwestern Ry., and for about half the distance the right of way is adjacent to that of the latter road. As on many interurban electric roads the location was governed largely by right-of-way considerations. The maximum grades are 2% in the direction of the loaded traffic, and 3% in the opposite direction. Freight will be carried, and a large milk business is expected. The sharpest curves are of 200 ft. radius. There are five plate girder bridges, and several small openings spanned by I-beams. The road is single track, laid with 60-lb. T-rails, 30 ft. long, spliced with Weber joints. It has double pole lines, with span wires supporting the trolley wires. Power is furnished by the Rockford Edison Co. The line is owned by the Rockford & Belvidere Electric Ry. Co., of Rockford, Ill.; and was built by the Illinois Interurban Construction Co., which is composed of the same parties. Mr. C. C. Stowell, M. W. Soc. C. E., of Rockford, is Chief Engineer. Mr. T. M. Ellis is Superintendent of the Rockford & Belvidere line, the Rockford City electric railways, and the new line now under construction from Rockford north to Beloit and Janesville, Wis.

METHODS OF CONSTRUCTION OF THE 3,820-FT. STONE ARCH BRIDGE AT ROCKVILLE, PA.; PENNSYLVANIA R. R.

In our issue of May 10, 1900, we illustrated and described the plans for the long double-track stone arch bridge for the Pennsylvania R. R., at Rockville, Pa. This structure is now practically completed, and will be put in operation as soon as the necessary changes have been made in the tracks at each end. Fig. 1 gives a fairly good view of the completed bridge. Briefly described, it

FIG. 1. VIEW OF DOUBLE-TRACK STONE ARCH BRIDGE AT ROCKVILLE, PA.; PENNSYLVANIA R. R.

Wm. H. Brown, M. Am. Soc. C. E., Chief Engineer Pennsylvania R. R. Drake & Stratton and H. S. Kerbaugh, Inc., Contractors.

crosses the Susquehanna River at Rockville, Pa., and replaces a double-track, three-truss bridge of twenty-three 240-ft. spans. The new stone structure is 3,820 ft. long and 51 ft. wide over all. It consists of 48 70-ft. arch spans, in which the arch rings, spandrel walls and pier facings are of stone, and the filling and backing are of concrete. The contractors for the bridge were Drake & Stratton, of Philadelphia, Pa., for the east half, and H. S. Kerbaugh, Incorporated, for the west half.

Work was begun simultaneously by the two contractors, and they used substantially the same methods and duplicate plants. The first construction work was the placing of the pier footings. This was done by means of cofferdams built on shore, floated into position and sunk. At the site of the bridge the water is shallow, and has a comparatively slow current. The river bed is a smooth and regular rock. Practically all that required to be done to build the footings, therefore, was to sink the cofferdams in water scarcely ever more than 3 ft. in depth, lay the interior dry, remove the unsound surface rock, level up the excavation and lay the concrete footings. The necessary pumps and derricks were installed on flat-boats and the construction material was delivered along the work by means of a temporary trestle running parallel to and close alongside the bridge site. The piers were built of a rock-faced ashlar facing and a Portland cement concrete backing.

The arches were built on truss centers, each center being half the width of the arch ring. Fig. 2 shows the construction of the centers in detail. Each center consisted of eight parallel trusses, with a horizontal bottom chord and a segmental top chord, made up of sawed timbers having the dimensions shown by Fig. 2. In this illustration attention may be called to the cruciform section of the web members; to the gusset plate connection of the top and bottom chords at the ends of the trusses; and to the wedge support of the trusses and the adjacent rollers at the pier bents. These bents were two-story bents and had their bottom sills resting on the set-offs of the concrete pier footings. Fig. 3 shows the centers in place ready for the erection of a number of the arches.

The arch rings were built in longitudinal halves. One-half of the ring from the side to the center line was constructed, then the center was lowered onto the rollers by knocking out the wedges, and pushed over into position for the second half, which was erected and thoroughly bonded with the half which had been previously constructed. After the completion of the arch ring, the spandrel walls were built and the filling was put in place. When the whole ring was completed the center was shifted to the next span by boom derricks mounted on the scows which had been used for building the piers. To handle the materials on the bridge boom-derrick travelers were employed, running on a trestle work carried by the centers or by the completed arches. One of these travelers is shown at the left in Fig. 3. Altogether six travelers were used, three at each end of the bridge. The mortar was mixed by hand on the bridge as used, but the concrete was mixed in cubical mixers on shore and taken to the work by narrow-gage cars running on the temporary trestle shown in Fig. 3.

The plans for the bridge were prepared by the engineers of the Pennsylvania R. R., Mr. Wm. H. Brown, M. Am. Soc. C. E., Chief Engineer, and Mr. Geo. Nauman was the engineer in charge of the work for the Pennsylvania R. R. Co. We are indebted to H. S. Kerbaugh, Incorporated, for the information from which this article has been prepared.

THE EARLY HISTORY OF OPEN-HEARTH STEEL MANUFACTURE IN THE UNITED STATES.

By Samuel T. Wellman, M. Am. Soc. M. E.†

The idea of making steel by an admixture of cast and wrought iron melted together on the open hearth in a reverberatory furnace was first proposed by the French philosopher, Reaumur, in 1722. We have records of this process being tried several times by different persons during the eighteenth and first half of the nineteenth century. In France, a commission appointed by the French Government under Louis Napoleon spent a large amount of money in experiments in trying to melt steel on the open hearth of a reverberatory furnace. They succeeded in reaching the necessary temperature, but all of these early experiments failed to be a commercial success, on account of the destructive action of the heat on the lining of the furnace.

The melting of steel in regenerative open-hearth furnaces was first proposed by C. W. Siemens in 1861. It was tried in a very small way, by one or two of his licensees, but we have no record of its having been put into successful use. Pierre & Emile Martin, at the Sireuil Works, near Paris, were the first to carry out the process on a commercial scale, they having built a furnace at their works in 1864, under a license from Siemens. Speaking of this furnace, C. W. Siemens, in a paper read before the Chemical Society, May 7, 1868, said: "It was chiefly intended for a heating furnace, but was so constructed of Dinas silica brick and of such form that it could be used as a melting furnace." Messrs. Martins' experiments with this furnace were quite successful, and soon became known all over the metallurgical world, creating a great deal of interest.

THE TRENTON FURNACE.

Among the many ironmasters who become interested in the process was Abram S. Hewitt, who purchased for his firm, Cooper, Hewitt & Co., of Trenton, N. J., the rights in the patents for America. Fred. J. Slade, their engineer, was sent over to France to study the process. When he returned home Cooper, Hewitt & Co. immediately started to erect a small furnace at their works in Trenton, N. J., to try the process. This furnace was of only 4 or 5 tons capacity. It was put in operation during the fall of 1868. The gas producers were of the regular Siemens type, and built from drawings furnished by Messrs. Siemens' agents in America. I was at the time assisting Messrs. Siemens' engineer, J. T. Potts, who had been sent to this country by C. W. Siemens to have charge of the erection and starting of the first regenerative furnace which was built in this country. This furnace was for the melting of crucible steel, and was built at the works of Anderson, Cook & Co., of Pittsburg, Pa. I was sent by Mr. Potts to Trenton to assist Mr. Slade in the starting of their gas producers, with which they were having some trouble. This gave me a good opportunity to see the first efforts to make open-hearth steel, and I have a very vivid recollection of some of these experiments.

Mr. Slade was the only man connected with the works who had ever seen a heat of open-hearth steel melted, and, as he was not a practical steel man, he probably overlooked some of the important points while watching the manufacture in France. At any rate, everything bad that could happen in the manufacture of open-hearth steel seemed to fall to their lot.

The furnace was a Siemens regenerative furnace, I suppose copied from one in use at Messrs. Martins' works, near Paris. It had a very flat, shallow bottom, but there did not seem to be much trouble in getting it up to a fair steel melting heat. The regenerators seemed to be of ample size, and the furnace fairly well designed for its work, excepting in the shape and depth of the bottom, which was entirely too shallow for the quantity of steel which it had to hold. On the casting side of the furnace, in front of the tapping hole, was fastened a kind of forehearth, called by the workman, from its shape, "a shoe." In the bottom of this, at the outer end, was placed a fire-brick nozzle, in which was fitted a fire-clay stopper, by which the flow was regulated. Running parallel with

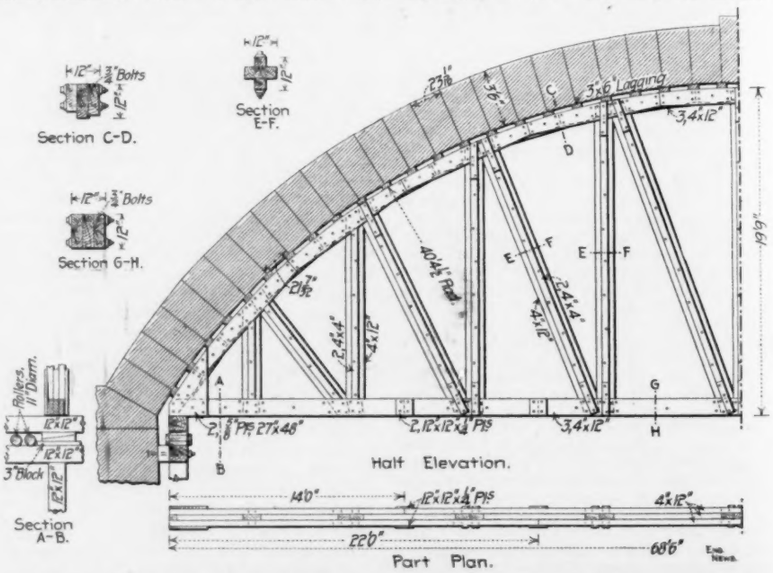


FIG. 2. DETAILS OF CENTERS FOR 70-FT. ARCH SPANS OF ROCKVILLE BRIDGE.

*Condensed from the presidential address at the Annual Meeting of the American Society of Mechanical Engineers.

†Gen. Supt. Wellman-Seaver Engineering Co., Cleveland, Ohio.

the front of the furnace, was a line of narrow-gage railroad, on which were placed the cars for the ingot molds, which were arranged for group casting. These cars were moved by a chain windlass placed at one end of the track. In all the heats that I saw made, franklinite pig iron was used for the bath, and the balance of the heat made up from puddled bars and scrap steel. This mixture should have made good steel, but unfortunately they had no ferro-manganese, none being made at that time in the country, and but little, if any, in Europe.

For recarbonization they used a small quantity of franklinite pig, according to my recollection not more than ½ to 1½% of the weight of the charge. As the franklinite contained only about 10% of manganese, this gave them a steel very low in that element, with, at the most, not more than 0.15%, and often only a mere trace. The result was a steel that was difficult to roll, except at a high temperature. It would stand a welding heat, and a dull red heat, but was yellow short, and any attempt to hammer or roll it at that temperature resulted in the steel going to pieces. If the furnace bottom had been made of magnesite or other basic material the amount of manganese would have been quite sufficient to have made the steel workable at all temperatures.

These are only examples of the difficulties and rough experiences which were encountered in these initial trials, and it was no wonder that poor Mr. Slade was discouraged. As is very often the case, this experiment was not very profitable to the pioneers, Cooper, Hewitt & Co. The furnace was operated at intervals for a year or two, but was finally abandoned. The manufacture was stopped, as it was not a commercial success. Those who saw these experiments were able to profit by them and avoid many of the difficulties encountered in them.

THE BAY STATE IRON WORKS FURNACE.

The second works to make open-hearth steel in America, and the first to make a commercial success of the manufacture, were the Bay State Iron Works of South Boston, under the superintendence of Ralph Crooker. Mr. Crooker was an ironmaster of the old school, and at the time of my association with him had been connected with the management of iron works, in one capacity or another, for over 50 years.

The Bay State Iron Co. had been manufacturers of iron rails for many years, but about this time the advent of steel rails had induced them to experiment in the manufacture of steel-headed rails. Their first experiment was

FIG. 3. VIEW OF ROCKVILLE BRIDGE IN PROGRESS OF CONSTRUCTION, SHOWING ARCH CENTERS, TRAVELER AND SUPPLY TRACK.

In the first heat at Trenton, when the melter thought from the small test ingots taken that the metal was ready to cast, a small quantity of spiegeleisen was added, and when this was melted a bent bar was driven through the sand wall between the shoe and the furnace. When this bar was withdrawn it allowed the steel to run out and fill the shoe to the level of the steel in the furnace. The stopper being opened, the steel ran out through the nozzle into the molds. When the first group was filled the stopper was closed, and the car was moved along until the next group came under the nozzle. In this manner about one-half of the molds were filled, when the nozzle in the bottom of the shoe began to close up by the metal chilling. It soon closed up entirely, and the car was then moved along until the next group of molds was in place under the nozzle, when the whole nozzle was lifted out of its place, and the steel then came with a rush for a short time. This operation was repeated until all the steel that was liquid had drained out of the furnace, but only a small proportion made ingots that could be rolled; the larger half were scrap.

The great difficulty in these pioneer days of steel-making was to teach the melters to maintain the steel at the proper temperature. The margin between the proper casting temperature of the steel and the melting point of the furnace itself was very limited—much more so than to-day, as at that time no silica brick were available, and we were obliged to use clay fire brick for the roof and sides of the furnace. Shortly after the heat which I have mentioned I saw an attempt made to cast a charge which had chilled in the nozzle, so that it could not be started again. By the time the shoe could be taken off the steel had chilled solid, clear back into the furnace, which was then shut down half full of steel. The next day the furnace was started up again. A quantity of pig iron was added and the steel finally all melted, but it was so slow in coming to a steel melting heat that the carbon was reduced, and several more additions of pig iron had to be made, until finally the furnace was overfilled, making it all the more difficult to get the proper temperature. It was finally tapped, but it was so cold that it chilled in the nozzle and the forehearth, so that when the latter was taken off the steel ran down over the nozzle, cars and tracks, welding the whole together, and making a mess that I was afterward told took two weeks to clear up so that the furnace could again be started.

with puddled steel, which was used in the head of the rail in place of the hard wrought iron, which had generally been used for that purpose. As this did not prove to be a success, Bessemer steel ingots were brought from Troy and rolled into bars, which were used in the pile to form the head of the rail; this also was unsuccessful. Bessemer steel as then made was found to be very irregular in quality, and sometimes impossible to weld. At this stage Mr. Crooker's attention was called to the experiments that were being made in the manufacture of open-hearth steel at Trenton. He visited the works, and after watching the process for some time he became convinced that with a properly-constructed furnace and the use of ferro-manganese a good weldable steel could be made. He tried to make some arrangements with Messrs. Siemens' agents to supply him with plans for a furnace such as he wanted, but, failing in this, he sent for me, I having left Messrs. Siemens' employ several months before this. I soon came to terms with him, and in a few weeks we had the plans well in hand and started the construction of the proposed works.

The erection of the works was started in 1869; they were completed in a few months, and put in operation early in 1870. The plant consisted of one furnace of a capacity of 5 tons. The necessary gas producers were also built, as well as a coal-fired preheating furnace. Several anthracite crucible steel melting furnaces were also built for the manufacture of ferro-manganese. The bath was made much deeper than the one at Trenton in proportion to its size. The metal was cast through a forehearth in much the same manner as at Trenton, but the ingot molds were carried on a large turntable resting on conical rollers, which was turned by a steam engine through the medium of bevel gearing. This made a very good arrangement, and as it was well designed and built, it gave no trouble in operation.

The Bay State plant started off with one very great advantage over that at Trenton, in that they had ferro-manganese to use for the final additions in the process. As this could not be purchased at that time, we were obliged to make it in crucibles.

The first steel was made from a mixture of puddled bar made in their own furnaces, with some scrap steel, melted in a bath of English West Cumberland hematite pig iron. This steel was rolled into bars about 7 ins. wide by 2 ins. thick. This bar was used for the top of the rail pile and formed about one-fourth of its weight, the remainder of the pile being made of old iron rails. The weld was apparently as sound as if it were iron on iron. Quite a large quantity of rails were made in this manner and were put into use, but the day of weldless steel rails had come, and while the steel-headed rails gave better results as to wear than those of iron, they did not begin to do as well in that respect as those of solid steel. They lacked the strength and stiffness of solid steel, and these latter qualities had as much to do with good wearing results as the mere difference of hardness of the head.

It soon became apparent to the Bay State Co. that the steel-headed rail was a failure, and that they must look to some other outlet for the product of their steel plant. They were large makers of iron plates as well as rails. Their flange plates had a good reputation, but were costly to make, being puddled from charcoal pig iron. Added to this expense was the tremendous loss from blistering, the average being from 40 to 50%. This meant that amount of the plate being cut up and worked over again—a very serious item of cost. These troubles, and the fact that some very good flange and fire-box steel had been made in Pittsburg in crucibles, induced them to experiment in the manufacture of soft steel plates, rolled from ingots made in the open-hearth furnaces. The first were made from their own bars, puddled from charcoal iron, but this was not satisfactory, as the iron contained too much phosphorus. After quite an amount of experimenting, a small quantity of steel was made from blooms made in the Lake Champlain district, direct from the ore in the old-fashioned Catalan forge. The result was most satisfactory; a beautifully soft, ductile steel was produced that was perfectly malleable, hot or cold. Plates rolled from it never showed a blister and very few defects of any kind, and most satisfactory of all was the fact that it could be produced much cheaper than the best iron flange plates. A great many samples of this plate were sent around to their different customers, and the company very soon secured a large trade in boiler and fire-box plates, which they were able to hold for several years. Only one furnace was ever built at the Bay State works, but this furnace was run day and night for several years in the manufacture of the highest class of ingots for boiler and fire-box plates. As the price was very high, this small steel furnace earned a great deal of money for the company.

FURNACES AT NASHUA AND PITTSBURG.

The next firm to build an open-hearth furnace were the Nashua Iron Co., at Nashua, N. H. This was a 5-ton furnace, built under license from Messrs. Siemens.

The steel was tapped from the furnace into a ladle mounted on a car running on rails, these being placed on each side of a deep casting pit, in which the ingot molds were placed. This pit ran at right angles to the furnaces, the ladle car being hauled by a chain and windlass worked by hand. This made a cheap and effective casting arrangement. For a stationary furnace, it had a great advantage over the use of a shoe, similar to those used on the Bay State and Trenton furnaces, as no matter how cold the steel was it was always hot enough so that it ran clean out of the furnace. While some of it might chill in the ladle, the furnace was not interfered with at all, and we were able to get out the next heat without interference from steel being left in the furnace.

The Nashua Company were large manufacturers of forgings for railroads and marine uses, and much of the steel made by them was used to take the place of iron for this purpose. They also secured quite a large trade in boiler and fire-box plates, and later on they commenced to manufacture steel for locomotive and car-wheel tires. Some years later this 5-ton furnace was torn down and a furnace of 10 tons capacity was built in its place.

About the same time that the Nashua Company were building their first furnace Singer, Nimick & Co., of Pittsburg, were building a furnace of about the same size, which was put in operation about the time of the one at Nashua. It was used for the manufacture of mild steel, principally for boiler and fire-box plates, which they had previously made from crucible steel.

THE OTIS PLANT AT CLEVELAND.

The works of the Otis Iron & Steel Co., of Cleveland, was the first plant in the United States to be built for the exclusive manufacture of open-hearth steel. I was engaged by the company to build and take charge of the works.

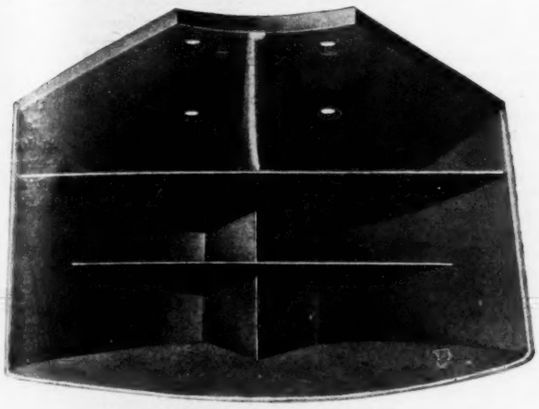
Ground was broken for the erection of the works in the summer of 1873, but they were not finished until the fall of 1874. At my suggestion Alexander L. Holley was appointed consulting engineer, and he served the company for several years in that capacity.

Many plans for the general arrangement of the works were worked over between us, and the one finally adopted, with some minor alterations, was one suggested by him. The steel melting plant, as originally built, consisted of two 7-ton furnaces with a regenerative preliminary furnace for preheating the blooms before adding them to the bath, and a regenerative crucible ferro-manganese furnace. The most radical improvement over old practice was the raising of the charging platform about 10 ft. above the general level, the material to be melted being raised by hydraulic elevators. This arrangement made the furnaces very accessible for repairs, and also gave

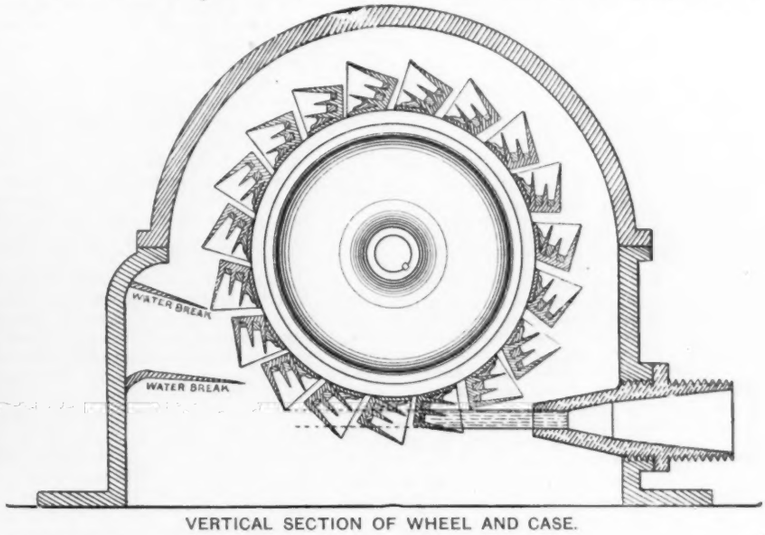
against the face of the cup until the blow is fully struck and is then directed outward against the curved sides of the bucket." The bucket shown in the illustration is evidently based upon a similar plan, the "splitter" being subsequently provided to clear away the water more rapidly. In fact we find in the catalogue of the De Remer wheel numerous expressions of which the following is an example:

The V-shaped lateral bars receive and stop dead the stream of water after it issues from the jet; they overcome the glancing blow ever present in feeding a circle through a tangent and characteristic of all other forms of tangential wheels.

It will be seen from the preceding that the object of this construction of the buckets is to bring the water of the propelling stream to rest relatively with the wheel, thus obtaining, according to the inventor, a maximum of efficiency. As to the disposition of the water after delivering its energy to the wheel, the maker's catalogue says, "the dead water is discharged by gravity and centrifugal force," it being further explained that gravity is the chief agent in the discharge when the wheel operates under low heads of water, centrifugal force under high heads. It may be doubted whether the action of the wheel and the movement of the water are exactly in accordance with the inventor's explanation. It seems probable that the "splitter," in conjunction with the outwardly-flaring sides, turns and reverses the water in a more or less continuous stream, very much as do wheels of the Pelton type.



PERSPECTIVE VIEW OF BUCKET.



VERTICAL SECTION OF WHEEL AND CASE.

FIG. 1. THE DE REMER "TANGENTIAL IMPACT" WATER WHEEL AND BUCKET.
De Remer Water Wheel Co., Denver, Colo., Mfrs.

Some tests of the De Remer wheel are reported in the manufacturers' pamphlet. A comparative test was made by Prof. R. C. Carpenter, at Ithaca, N. Y., about two years ago, with a 12-in. De Remer, and a 12-in. Pelton wheel. Efficiency curves of the two wheels for varying velocity were plotted from results obtained by using, in successive experiments, nozzles of ⅝-in., ½-in. and ⅝-in. diameter. These curves are shown in Fig. 2. The efficiency curve of the De Remer wheel is seen to rise above the Pelton curve for low velocities, results noted. When the Pelton wheel was started first, the stream on the De Remer caused the coupled wheels to slow up and come to a standstill. When the De Remer wheel was started first, turning the stream on the Pelton had the effect of slowing the couple down to 176 r. p. m., which speed remained constant, the De Remer being the driving wheel. When run independently and without load, the two wheels showed free velocities of 1,660 r. p. m. for the Pelton and 1,488 r. p. m. for the De Remer, both under 142 ft. head. The nozzles in use at the time were furnished by the manufacturers of the two machines; the Pelton nozzle was found to have a slightly higher discharge than the De Remer under the same head.

It will be apparent, of course, that tests like these are of not much practical value, having but little bearing on actual operation of such wheels. The action of the water upon the buckets is different for every speed of the one relative to the other; in any one wheel it is designed to be a commercial maximum with a particular speed of wheel and a particular velocity of stream; backward running of the wheel is a condition the farthest possible removed from that of maximum efficiency. It is clear, too, that a bucket construction ensuring most efficient operation at one rotation-speed may at another speed be considerably less efficient than some other form of construction. Aside from this question of efficiency, the test noted, of running two wheels belted together, involves the effective radius of action of the two wheels. For instance, though both wheels were rated as 12-in. wheels, the lower speed of the De Remer when running free, and its behavior in the reversal tests, indicate that it has a larger effective radius than the Pelton, which, other things being equal, would give it the greater starting torque and in general the greater torque at equal speeds.

More direct comparisons between the wheels are afforded by the curves of efficiency obtained by Prof. Carpenter and shown in Fig. 2. It is seen at once that the Pelton wheel tested had a lower efficiency at rim-speeds up to about half the water velocity, and a higher efficiency than the De Remer at speeds above this point. An interesting feature of the curves is the fact that the maximum efficiencies on the three sets of curves lie at about the same point, having a velocity-ratio of about 0.40; the maximum efficiency is seen to be from 5 to 10% greater for the De Remer than for the Pelton in the curves shown. (Presumably the rim-speeds were figured on a diameter of 12 ins.; they would, therefore, since the 12-in. represents the diameter over buckets, be subject to a correction of different amount for the two wheels. This correction would result in shifting all the curves to the left with respect to the velocity-ratio values, i. e., the maximum efficiency point would correspond to a lower velocity-ratio than 0.40).

It will be noted that both wheels show on these curves maximum efficiencies of between 80 and 90%. This would indicate that they operated fully as efficiently as larger wheels of their class.

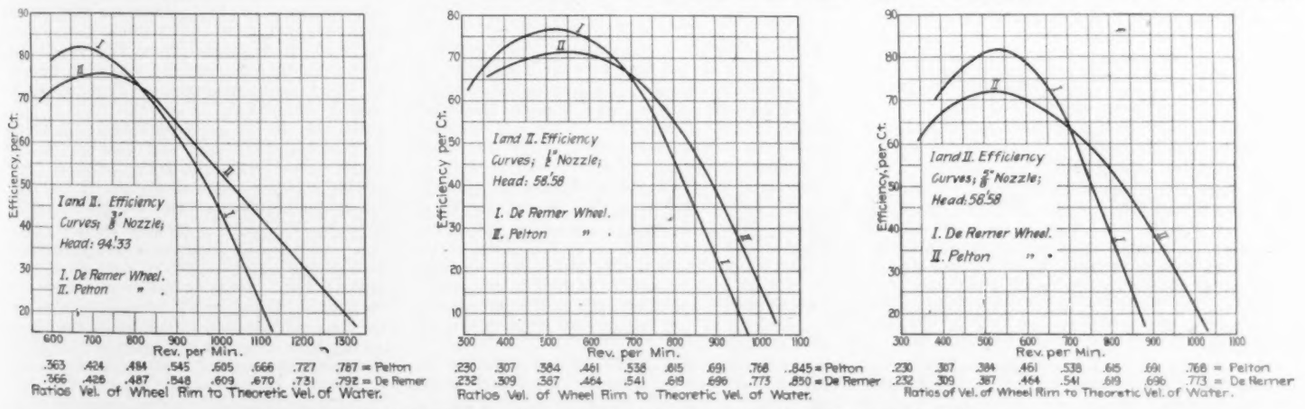

Efficiency per Ct.
I and II. Efficiency Curves; ⅜" Nozzle; Head: 94.33
I. De Remer Wheel.
II. Pelton " .
Rev. per Min.
.363 .424 .484 .545 .605 .666 .727 .787 = Pelton
.366 .426 .487 .548 .609 .670 .731 .792 = De Remer
Ratios Vel. of Wheel Rim to Theoretic Vel. of Water.
I and II. Efficiency Curves; ½" Nozzle; Head: 58.58
I. De Remer Wheel.
II. Pelton " .
Rev. per Min.
.230 .307 .384 .461 .538 .615 .691 .768 .845 = Pelton
.232 .309 .387 .464 .541 .619 .696 .773 .850 = De Remer
Ratios Vel. of Wheel Rim to Theoretic Vel. of Water.
I and II. Efficiency Curves; ⅝" Nozzle; Head: 58.58
I. De Remer Wheel.
II. Pelton " .
Rev. per Min.
.230 .307 .384 .461 .538 .615 .691 .768 = Pelton
.232 .309 .387 .464 .541 .619 .696 .773 = De Remer
Ratios of Vel. of Wheel Rim to Theoretic Vel. of Water.

FIG. 2. EFFICIENCY-SPEED CURVES FOR 12-IN. DE REMER AND PELTON WHEELS.

the great advantage of our being able to have a very shallow casting pit. This plan is still followed by the latest and best works in this country.

The steel was tapped into a ladle, as at Nashua, only instead of supporting the ladle on a car it was carried on the arms of a jib crane, which was simply a swing, without any lift. This made a simple and cheap casting arrangement and one that was perfectly safe. The one crane stood on the center line between the two furnaces and the ladle swung around to the tapping spout of each. There being no lifting of the ladle when it was filled with metal, there could be no breakdowns or upsetting.

The first heat of steel was made in October, 1874, from charcoal blooms from the Lake Champlain district, melted in a bath of Lake Superior charcoal pig iron. This steel was naturally of very high quality and was made into plates for fire boxes.

Of course we had to educate all of our skilled men; we had no works to go to from which to hire them, and so had no other way except to educate them.

When I severed by connection with the company, after 16 years' service, out of about 1,000 employees, I was able to learn of only one skilled workman who had not learned his trade in the shops of the company.

Not only men, but all of our materials, had to be tried and proven. The question of fire brick, as well as of other refractories, was an important and troublesome one, and a great deal of experimenting had to be gone through with before the best materials could be found. In the meanwhile we were building up a good reputation for the quality of our product, which was principally plates for boilers and fire boxes. Otis steel was for many years a standard brand for the purpose in this country, and sold at the very highest price.

In 1878 two 15-ton furnaces were added to the plant. These were a great success from the very start, and were at that time regarded as of immense size. They were a radical step in advance of anything that had been built up to that time. In 1881 two more 15-ton furnaces were added, and in 1887 two more of the same size. The Otis works were at one time the lrgest open-hearth plant in this country.

As I have said, the principal raw material used at the start for making the high quality of soft steel which was turned out at the Otis works was charcoal blooms from the Lake Champlain district. These were used in largely increasing quantities from year to year, until the consumption reached as high as 12,000 to 15,000 tons per year, at an average cost of $45 to $60 per ton. This seems like an enormous price to pay for raw material. It was; but as the finished plates were sold at from $135 to $160 per ton, a fairly good margin was left for profit. Later on a larger amount of puddled blooms were made from Bessemer pig iron in mechanical puddlers. Washed metal made in revolving Pernot furnaces by the Krupp-Bell process was also used.

THE FIRST BASIC STEEL.

The first basic steel produced in this country was made at the Otis works in 1886. During a visit to Europe in 1885 I saw the process at work, and was much impressed with its possibilities. I immediately arranged to have a small cargo of Styrian magnesite sent over, and as soon as we could spare a furnace to make the experiment we put in a lining of calcined magnesite on top of the silica bottom, which had been melted down as low as possible. This magnesite was not fused in, as is the practice in these days, but after being mixed with tar was rammed in place while the furnace was cold. This was the practice in Europe at that time, and we simply followed out what we had seen on that side of the water. As soon as the bottom was made, we started up the furnace, which was operated experimentally for some four months, making a good quality of basic steel. All of it went to our regular customers in our regular work, without any fault being found. It was kept as a great secret, and no one outside of the company's works knew what we were doing.

During all of this time we were extremely busy. The basic process was much slower in operation than the acid, and this made the output of the furnace so small that I was at last forced to yield to the pressure brought by the selling department for more steel, and changed the furnace back to the acid process. Some months later the basic process was started at the Pennsylvania Co.'s works at Harrisburg and the Carnegie works at Homestead. To-day at least three-fourths of all the open-hearth steel made in America is manufactured by the basic process, and this proportion is bound to increase. It is my opinion that there is no question about the fact that the very best qualities of all grades of open-hearth steel can be made cheaper and better by the basic process than in any other way. The basic process of steel making is so simple, both in theory and practice, that it seems strange that it was not thought out and put in practice before it was. The same principles are involved, and the same reactions go on in the puddling process which has been in use for generations. The only difference is that the temperatures are lower in the puddling furnace than in the open hearth; as a consequence, the lining in the latter must be the more refractory.

RECENT DEVELOPMENT OF THE OPEN-HEARTH PROCESS.

Very soon after the Otis Steel Works were started, open-hearth furnaces began to be erected all over the country. They were built by the Pennsylvania Steel Works, at Steelton, Pa.; Cleveland Rolling Mill, at Newburg, near Cleveland; the Shoenberger Works, at Pittsburg, and many others, among all of which the Carnegie Works, at Homestead, was the most important. This is to-day the largest open-hearth plant in the world, consisting of 48 furnaces, of a capacity of from 40 to 50 tons each, having a total capacity of at least 1,300,000 tons per annum. The size of furnaces has increased from the little 5-ton furnace at Trenton and Boston up to those having a capacity of 50 tons, which is the average size now being built. Furnaces of this size nominally, at Ensley, Ala., have made heats yielding 74 gross tons of ingots.

Furnaces of 100 tons capacity are being built, and designs have lately been made for a furnace which will probably be built of 200 tons capacity. These large furnaces, however, are not properly melting furnaces, as the bulk of all the iron is charged into them in a liquid state, direct from the blast furnace. They might more properly be called "converting furnaces."

The output of open-hearth steel has grown from 893 tons in 1869, to 3,402,552 tons in 1900, against 6,684,770 tons made by the Bessemer process in 1900. But few new Bessemer converters have been built in this country for several years, and it is not likely that many more will be built. The production of basic open-hearth steel in this country will soon exceed the Bessemer in tonnage. Holley used to say, "The open-hearth process will some day go to the funeral of the Bessemer." It will be many years before that will come to pass, but the day is not far distant when the great bulk of all the steel in this country, at least, will be made on the open-hearth of the Siemens regenerative furnace by the basic process.

ANNUAL MEETING OF THE NEW JERSEY SANITARY ASSOCIATION.

The annual meeting of the association was held at Lakewood, N. J., Dec. 6 and 7. The opening session was occupied with a presentation of "The Legal and Sanitary Status of Garbage Disposal in New Jersey." The legal aspects of the subject were set forth in a comprehensive paper by Mr. Edwin B. Goodell, Attorney of the Montclair Board of Health. Under specific legislative acts passed in the last six years any city may collect and cremate garbage, or contract for the same; cities of 12,000 or less, instead of being limited to cremation, are permitted to solve the garbage disposal problem in accordance with their best judgment; all municipalities, regardless of size or class, may grant franchises for garbage crematories.

The sanitary aspects of the subject were presented by Mr. M. N. Baker, of the editorial staff of this journal. From information collected for a forthcoming "Municipal Year Book" it was shown that of 57 incorporated places of 3,000 inhabitants and upwards in New Jersey four only have improved means of garbage disposal. Atlantic City, Camden and Trenton, have garbage crematories, while at Paterson a private company treats the garbage by a partial system of reduction.

In the discussion on these papers Dr. Henry Mitchell, Secretary of the State Board of Health, said that a weak point in the sanitation of the state had been pointed out. In the provision of pure water for its inhabitants New Jersey is ahead of most other commonwealths, but it has done very little in the way of garbage disposal. A member from Atlantic City told how $130,000 or so had been expended in garbage furnaces there, half of which was probably needless expenditure due to bad management and lack of good engineering. Dr. J. L. Leal, of Paterson, said that the contract price for the collection and disposal of garbage, ashes and dead animals in Paterson is now $30,000 year.

The evening session was opened by the address of the president, Mr. Herbert Baldwin, City Chemist of Newark, N. J. His topic was "The Public Water Supplies of New Jersey." He showed that few if any of the states of the Union have so large a proportion of their inhabitants under public water supplies as does New Jersey. In 1900, the state fell below Massachusetts in its typhoid fever mortality, New Jersey showing 19 deaths per 100,000, against 22 for Massachusetts. The demand for more and better water in New Jersey is being met by rapid increases in the development of both underground supplies and filtration works. There are now eight mechanical and three slow sand filtration plants in the state and soon there will be completed a large mechanical filtration plant at Little Falls, N. J. (see Engineering News, May 9, 1901).

A paper was read by Prof. Olin H. Landreth, of Schenectady, N. Y., on "The Sanitary Aspects of the Reclamation of Meadow Land." The author traced in some detail the benefits due to marsh drainage in different parts of the world, as shown by mortality statistics and the opinions of local observers. He thought it was hardly proven, as yet, that the only reason why marsh lands are malarious is because they are breeding places for mosquitoes; or, at least, that other qualities of marshes are not predisposing causes of malaria.

Mr. Wm. Lyman Underwood, of the Massachusetts Institute of Technology, told how Belmont and Cambridge, Mass., had drained some marsh lands, with a subsequent decrease in malaria. He also cited facts, from [illegible] own experience, to show that goldfish eat mosquitoes [illegible] ing. gested that others might, like himself, introduce water lillies and gold fish in ponds where the use of [illegible]sene would be objectionable, thus providing pleasure [illegible]ures as well as killing mosquitoes. A gentleman who had resided in Palestine confirmed the statements regarding the efficacy of gold fish in the destruction of mosquitoes.

Mr. H. Brewster Willis, of New Brunswick, was elected president of the association for the ensuing year, and Dr. Jas. Exton, of Arlington, was re-elected secretary.

NOTES FROM THE ENGINEERING SCHOOLS.

WORCESTER POLYTECHNIC INSTITUTE.—This is, we believe, about the only engineering school in the United States where commercial manufacturing work is carried on. At the Washburn shops of the Institute special drill-grinding machines are manufactured under patents owned by the Institute. The validity of these patents has been the subject of litigation for three years past, but we are informed by Mr. C. A. Chandler, the Superintendent of the shops, that a decision has just been rendered by Judge Wing in the U. S. Circuit Court for the Northern District of Ohio, in which these patents are fully sustained.

MAGNALIUM is an alloy of magnesium and aluminum, that is only now being studied as to its true properties, owing to a previous difficulty in obtaining the metals in a pure state. As quantities of magnesium, varying from 5 to 30%, are added to the aluminum, a harder and harder alloy is obtained, and the 30% alloy has a hardness intermediate between that of bronze and steel; with 50% of magnesium the alloy becomes very hard, but is brittle, will break under a hammer blow, but it takes a magnificent polish. The most useful alloys, however, are those containing from 25 to 30% of magnesium. The chemical stability of the alloy is slightly superior to that of the two metals separately; and this alloy can be easily cast into very complicated but homogeneous forms. In preparing this alloy the two metals are melted separately and the liquid aluminum is poured into the liquid magnesium at a temperature of 650° C. The cost of this alloy, says "Le Genie Civil," is still considerable, but its manufacture on any large scale would much reduce the present cost.

A "TANGENTIAL IMPACT" WATER WHEEL.

There has recently been put upon the market* a new style of impulse water wheel, built under the patents of Mr. Jared R. De Remer, of Denver, Colo., and described by him as a "tangential impact" water wheel.

In general appearance and arrangement the new impulse wheel is similar to the well-known existing types; it has a series of buckets arranged on the circumference of a power wheel mounted adjacent to one or more nozzles, each of which discharges a jet of water tangentially to the wheel against the buckets. The buckets are of unusual form, which form constitutes the main patented feature in this wheel. One of the buckets is shown at the left in Fig. 1. The holes in the upper side are for bolts for attaching the bucket to the wheel rim; the direction of the water-jet would be almost normal to the view-plane. The transverse wedge-shaped diaphragms are intended to prevent motion of the water in the bucket, and the shape of the sides, tapering back to form a pocket in the center line of the bucket and in the plane of the wheel, is designed to contribute to the same end. The smaller wedge-shaped body running transverse to the diaphragms is intended to act as a "splitter," and according to the inventor it is "of sufficient dimension only for the cutting-off stream to drive the water far enough to the sides to clear the following buckets." A diagrammatic section of the assembled wheel is shown at the right in Fig. 1. The position of the buckets relative to the wheel is shown here, as is also the relation of both to the incoming stream of water.

The form of bucket shown is a development of the inventor's original idea exhibited in the patent specifications. The claims and drawings of the patent show a bucket "having on the inner face of its outwardly projecting portion a series of corrugations concentric with the periphery of the wheel, and also having concaved sides extending from the ends of said corrugations." The specification describes the action of the bucket as follows: "Upon the water striking against them (the corrugations) it will be held, so to speak,

*By the De Remer Water Wheel Co., of Denver, Colo.

gress is in better position to act than was its predecessor a year ago. That body had before it only a preliminary report of the Isthmian Canal Commission (published in Engineering News December 20 and 27, 1900). The present Congress has received the complete report of the Commission, and has thus fuller and more complete data to guide its action than has ever before been available.

From the advance abstracts issued to the press, it appears that the Commission's final recommendations differ little from those contained in the preliminary report a year ago. The Nicaragua route is favored as it was a year ago; but a careful comparison is made between it and the Panama route. The final estimate of cost for the Nicaragua route is $189,864,000, as compared with $144,233,000 for completing the Panama work; but the cost of buying out the Panama concession is set at $109,141,000. The estimate of the cost of operating and maintaining the two canals is $1,350,000 larger for the Nicaragua canal, but it can be completed in eight years, while ten years would be required to finish the Panama work. The Nicaragua route is more advantageous for commerce except that to the west coast of South America, is better for sailing vessels and offers better hygienic conditions.

Already bills providing for the construction of the Nicaragua canal have been introduced in both houses of Congress, and while more or less delay is certain before they can pass through the necessary routine and be reached on the program of legislation, it seems well-nigh impossible that any obstruction can avail to prevent their passage. So strong is the sentiment in favor of such legislation that the committees having such bills in charge can well afford to take the time for carefully studying the measures presented and providing not only for the construction of the works but that such construction shall be carried on with the greatest possible safeguards against corruption, extravagance, or incompetent management.

We have always urged that when the work is finally undertaken it should be placed in charge of a thoroughly competent commission. This is the plan of procedure which has been followed with the most excellent results in a large proportion of the great public works which have been carried out by municipalities and states during recent years. Such works as the New York Rapid Transit Railway, the Boston Subway, the Chicago Drainage Canal, the New Orleans Drainage system, the Detroit Public Lighting system are examples of works carried out under this plan.

At least one bill already introduced in Congress provides for the construction of the Nicaragua Canal by such a commission as we have suggested. It is much to be hoped that this feature may be embodied in whatever measure finally receives the approval of Congress.

LETTERS TO THE EDITOR.

Why the Keystone Dropped.

Sir: The vertical joints of the keystone on the Portsmouth school building (Eng. News, Dec. 5) were improperly, "if ever," made, and the pointing held it in place until the settlement. The reason that the arch did not settle uniformly, was that the other joints between the stone forming the arch, being well made up, were well plastered, forming a secure bond. The two half arches acted as cantilevers. J. S. A.

New York, Dec. 7, 1901.

(Another New York correspondent gives a different explanation; but the above is doubtless the correct reason.—Ed.)

Temperature Stresses in the Stiffening Trusses of Suspension Bridges.

Sir: I find in your number of Nov. 28, under the above quoted heading, a letter by Mr. Lindenthal expressing views on this subject directly opposite to those advocated by me in previous numbers of your paper.

The whole design of suspension bridges depends upon the correct calculation of the stresses here considered. If the views of Mr. Lindenthal and Professor Melan were correct, a suspension bridge with three hinges and high stiffening trusses would be an uneconomical and absurd design. The same would apply to arches with three hinges. Mr. Lindenthal states that he was the first to draw attention to the very large temperature stresses in high, three-hinged stiffening trusses of suspension bridges.

Such an assertion, differing from the prevailing views of other authorities, should be accompanied by proof of its truth. All the proof given by Mr. Lindenthal and Professor Melan is substantially as follows:

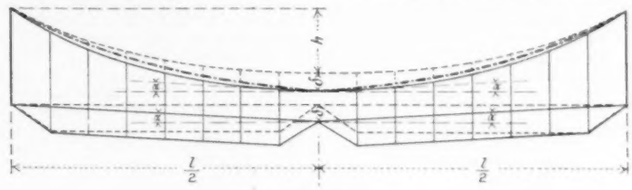


Fig. 1.

We consider a three-hinged stiffening truss such as is shown in the accompanying Fig. 1 supported from cables which are so adjusted that they are parabolas at a given load and temperature. If either the load or temperature or both increase, the cables lengthen and they and the trusses drop at the center. If the trusses of each half-span remained straight, the cables of the two half-spans would, if the lengths of suspenders are unchanged, form angles at the center, as shown by the heavy dash and dot line. But the trusses are flexible; according to Prof. Melan this reduces the angles of the cables at center. Mr. Lindenthal and Professor Melan assume for the purpose of calculating the temperature stresses that each cable in its lower position, as well as in the upper one, is one parabola from end to end of span. They then find that the consequent deflection of the suspended stiffening trusses of each half-span, at their centers, is equal to one-quarter of the drop of cables at center of span. From this deflection of stiffening trusses, the stresses in their chords are calculated.

Professor Melan concedes that the cables in their lower positions are not parabolas extending from end to end of the span, but form angles at the center of the span, and that the formulas he obtains for the temperature stresses in stiffening trusses give therefore excessive results. He, however, believes these results to be approximate.

The whole argument by means of which Mr. Lindenthal and Professor Melan obtain their formulas stands and falls with the truth or falsity of the proposition that the cable in each position is one parabola with its vertex at the center of the span. Neither of them gives any proof of even the approximate truth of this proposition. The formulas derived from it are of little value and are grossly misleading as will appear from the proof which follows.

I gave in your number of Nov. 7 a proof for the calculation of temperature stresses in three-hinged stiffening trusses of suspension bridges, applying to the usual case when the spans of cables and stiffening trusses are different. The proof becomes much simpler if both these spans are alike, as is assumed by Mr. Lindenthal and Professor Melan.

Mr. Lindenthal is not convinced by my proof and tries to show the absurdity of my formulas by applying them to shallow stiffening trusses. He overlooks my statement that the formulas give approximate results only for high trusses, and that a correction, taking account of the deflection of the stiffening trusses, must be made for low ones.

The results obtained by my formulas are, however, too large in every case and are, therefore, always on the safe side. The correction necessary for shallow trusses was made in the Brooklyn Bridge report.

I will now give the simpler proof for the case when cables and stiffening trusses have equal span, with the correction necessary on account of the flexibility of the stiffening trusses.

We assume the cables of the whole span to be parabolas for a given load and temperature. If either load or temperature or both increase, the cables lengthen and take a lower position. The two half-spans of stiffening trusses, which we assume to be horizontal for the original position of the cables, drop at the center and meet there at an angle.

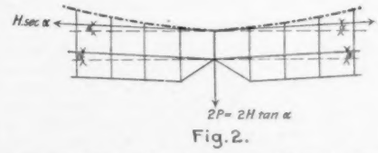


Fig. 2.

We will first consider the stresses that would arise if the stiffening trusses were rigid and afterwards take into account the effect of their deflection. If the stiffening trusses of each half-span remained straight, their angle at the center of the span with the horizontal would be α where $\tan \alpha = \frac{2\delta}{l}$; δ being the drop of cables at center of span and l being the span.

We will assume the suspenders very near together, so that the cables are curves and not polygons. In this case the cables, being held by the suspenders at a fixed distance from stiffening trusses, will also form at center of span an angle α with the horizontal. The forces acting at the center of canles are as in Fig. 2.

If H is the horizontal component of stress in cables and w is the load per lineal foot of bridge carried by cables, inclusive of their own weight and if h is the dip of the cables, then

$$H = \frac{w\, l^2}{8\, h}.$$

The cables will exert an upward pull 2 P at center of span, equal to 2 H tan α. One-half of this will go into the stiffening trusses of each half-span. If we introduce the values of H and tan α, above found, we obtain

$$P = H \tan \alpha = \frac{w\, l\, \delta}{4\, h}.$$

As shown in your number of Nov. 7, the cables in each half-span will be parabolas, the suspender pulls will therefore be uniform between ends of half-spans. The forces acting on each half-span in consequence of the drop of cables at center are therefore a uniform force extending over the whole length of half-span, a force equal to P acting at center of span and an unknown reaction at end of span. This unknown reaction must evidently be equal to P since the half-span is uniformly loaded. The vertical forces acting on the half-span are therefore two end reactions each equal to P, and the uniform downward force T per lineal foot of half-span. The equation stating that the vertical forces are equal to 0 is:

$$T \cdot \frac{l}{2} - 2P = 0.$$

Therefore

$$T = \frac{4P}{l}.$$

If we introduce for P the value above found we obtain

$$T = \frac{w\, \delta}{h}.$$

This formula is obtained from that given in your number of Nov. 7, if in the latter, L is made equal to l and (w + q) is changed to w which latter has now the same meaning as (w + q) had formerly. The result of the drop δ of cables and stiffening trusses at center of span is therefore the same as the application of a load T per lineal foot of bridge on a span equal to the half-span of stiffening trusses and freely supported at both ends. This result enables us to calculate the temperature stresses which would exist if the stiffening trusses were absolutely rigid. In reality these trusses are flexible and are bent downwards in consequence of the temperature stresses in them. The cables connected with them are bent downwards the same amount as the corresponding points of the trusses below. The curvature of the cables is thereby increased. This has the effect of increasing the suspender pulls and diminishing the load which has to be carried to its ends by each half-span of stiffening trusses. The angle of stiffening trusses of the two half-spans meeting at center of span, and that of the cables just above is diminished, and the force acting on stiffening trusses at center of the span is thus reduced.

Since doubt has been expressed on this subject, I give in the following a method of calculating the effect of the flexibility of the stiffening trusses on their temperature stresses.

If d is the depth of stiffening trusses, and if the unit stress per square inch in their chords due to temperature stresses is s, then the trusses of each half-span will be bent approximately in the arc of a circle. The diameter of this circle is:

$$D = \frac{E\, d}{s}.$$

The deflection at center of half-span is:

$$\eta = \frac{l^2}{16\, D} = \frac{l^2\, s}{16\, E\, d}.$$

The angle between tangent to bent axis of half-span at center of span, and its straight axis is β where

$$\tan \beta = \frac{2\eta}{\frac{l}{4}} = \frac{8\eta}{l} = \frac{l\, s}{2\, E\, d}.$$

The angle of tangent to bent axis of half-span, at center of span, with the horizontal is ($\alpha - \beta$). Since both angles α and β are small, tan ($\alpha - \beta$) is approximately equal to

$$\tan \alpha - \tan \beta = \frac{2\delta}{l} - \frac{l\, s}{2\, E\, d}.$$

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Apropos of our remarks in our last issue concerning the failure of the St. Lawrence route for export traffic to fulfil the extravagant prophecies made concerning it, the following figures which have just come to hand speak more eloquently than words. They are the record of the foreign shipping at the port of Montreal during the past four seasons of navigation:

	1898.	1899.	1900.	1901.
No. of ships	516	434	416	376
Tonnage	1,212,747	1,092,955	1,038,234	988,018

At the annual meeting of the American Society of Mechanical Engineers last week, the proposal to increase the annual dues of the society to $25 per annum was "snowed under" by a vote of 647 to 191. The long debate which preceded the ballot, and of which we have given a summary in our report of the meeting elsewhere, revealed a condition of the society's financial affairs and a method—or lack of method—in the conduct of its business which was in itself the amplest justification for every ballot cast against the proposal to raise the rate of dues.

The member of the Council (the society's governing body) who opened the debate with a motion to raise the rate of dues, in the same breath informed the members that during the past four years the society has accumulated a debt to its printer of over $13,000 (a net deficit of about $10,000 when collectible cash assets are deducted). Later developments in the discussion showed that not only has no report of this deficit ever been made to the members, but it was confessed that the Council itself was ignorant concerning it until its meeting on Oct. 31 last. It must be understood that, while the society has been running in debt to its printer, it has at the same time been paying off its second mortgage bonds out of the surplus which was accumulated by the simple device of letting its debts go unpaid. In the annual reports of the Council and of the Finance Committee, the society has been represented as in a highly prosperous condition. A year ago, for example, the report announced the payment of the second mortgage on the society's house, and that steps would next be taken to gradually reduce the first mortgage. Thus the membership, and by its own admission the Council itself, has been misled as to the society's real financial condition.

With a most singular lack of judgment, it was attempted to meet this deficit, which has amounted on the average for the past four years to $2,500 per year; by carrying through a proposition to so increase the membership dues as to give the society an increased income of about $20,000 a year. One member of the Council, with some display of temper, declared that it was the intention of the Council to keep this proposal to increase the dues as quiet as possible, until the matter was brought up at the annual meeting, and that had it not been for the public discussion of the topic in the technical journals the plan would have been carried through.

We should be sorry indeed, however, to believe that the Council as a whole deliberately adopted any such policy of secresy. In fact, the discussion revealed that the statements in official circulars to the effect that the Council and the Past-Presidents of the society were unanimous in favoring the increase of dues were wide of the mark. One Past-President headed an organization of New York members which led the opposition to the proposed increase. Another frank member of the Council confessed that until a very recent date two-thirds of the Council were strongly opposed to the increase. Other Council members who took part in the discussion withdrew their support from the measure.

It is only too evident that the officers and Council of the society have been in ignorance of the widespread dissatisfaction among the membership of the society with various features in the conduct of its affairs. The proposal to raise dues which are already larger than those of almost any other engineering society, has brought out a general expression of this dissatisfaction, and has been without doubt a revelation to the Council which will be of great value in influencing it to effect reforms. In fact it was announced at the meeting that it had already taken steps to reduce the society's expenditures by four or five thousand dollars per annum, and had also resolved to appoint a special committee to ascertain what steps should be taken to effect further economies and to remove causes for criticism on the part of members.

Subways for pipes and wires in New York city is one of the well-chosen subjects for investigation in 1902, proposed by the Merchants' Association of that city. As is well said in the December bulletin of the association, the proposed extension of the rapid transit system to the lower part of Manhattan Island affords an opportunity to install pipes and wires that should not be neglected. Before the work can be entered upon, however, legislation will be necessary, and to obtain that, public sentiment must be aroused to the desirability of the plan. The Merchants' Association will do a great service to New York, and to other cities, if it will present in a lucid manner the possibilities and advantages of subways for pipes and wires.

In our issue of March 15, 1900, we described the various European subways for pipes and wires, and advanced some of the many reasons for introducing them in New York city. Subsequently, it will be remembered, they were included in the plans for the Elm St. section of the rapid transit scheme, only to be given up later, on account of various complications. Sooner or later, subways are bound to come in the most crowded streets of our largest cities. It would be a pity if New York should again miss so excellent an opportunity to initiate the system.

Whatever opinion one may heretofore have held on the relation between mosquitoes and yellow fever, the experience of Havana, Cuba, during the month of October, can hardly fail to be regarded as striking evidence that the disease is spread by that troublesome insect. In the October report of W. C. Gorgas, Major and Surgeon, U. S. A., Chief Sanitary Officer of Havana, it is stated that not a single case of yellow fever was reported during the month, whereas:

> The maximum number of deaths from yellow fever since 1889, for this month, occurred in 1896, when we had 249 deaths; the minimum, in 1899, when we had 2 deaths; the average, 66.27 deaths; this year, no deaths and no cases. Last year, 1900, we had for October, 309 cases and 74 deaths.

As an explanation of this happy condition Major Gorgas says:

> The only change between last year and this is that since February we have carefully killed all mosquitoes in the neighborhood of every focus of infection, as it occurred. The infected house and all the adjacent houses in every case, have been carefully disinfected.

He also states that there has been an improvement in yellow fever conditions ever since April of the present year.

So firmly are Major Gorgas and his associates convinced of the soundness of the mosquito theory that the clothing of yellow fever patients is no longer disinfected. In fact, nothing has been done, of late, to prevent the spread of the disease except "to kill the mosquitoes which had bitten a sick person, and to prevent any more mosquitoes from biting, after the case was discovered."

THE NICARAGUA CANAL IN CONGRESS.

A year ago, just prior to the assembling of Congress, we expressed the opinion that a bill for the construction of the Nicaragua Canal would be passed during the session. That prophecy failed of realization on account of the opposition which developed to the ratification of the Hay-Pauncefote treaty with England to supersede the old Clayton-Bulwer convention. The failure to ratify the treaty was a practical bar to the enactment of any legislation for the construction of an Isthmian canal, and was so recognized by the ablest leaders in Congress. So, notwithstanding the almost certain prospect of the passage of a canal bill with which the session opened, its certain failure was speedily evident.

At the opening of a new session of Congress, however, we venture again to predict the passage of a bill for an Isthmian canal—and that canal the one at Nicaragua—at the present session of Congress. As all our readers who follow the newspapers are aware, a new Hay-Pauncefote treaty has been framed, has been presented to the Senate for its approval and has been favorably reported to the Senate by a unanimous vote of the Committee on Foreign Relations. At this writing the final vote in the Senate is still to be taken, but many of those who opposed ratification last year have had their objections removed by the changes which have been made in the new instrument, and from all accounts a favorable vote is to be confidently expected, and may even be recorded by the time this issue of Engineering News reaches its readers.

The new treaty supersedes in direct terms the Clayton-Bulwer treaty and enables the United States to undertake the construction of the canal and to have the exclusive right to its management and regulation. The United States agrees to make the canal a neutral waterway on the same basis as the Suez canal and assumes entire responsibility for its neutralization. It will be seen that the clause in last year's treaty which contemplated a general international agreement for the neutralization of the canal has been eliminated from the present instrument. This is a manifest improvement, since questions relating to the control of the canal are now effectually removed from the field of diplomacy, and the red tape and risk of international complications growing out of such questions are obviated.

With this treaty ratified, the next step will be the completion of the necessary arrangements with Nicaragua and Costa Rica. With the former government, indeed, negotiations are said to have been already concluded. A press dispatch from Managua on Dec. 9 reported the signing of a protocol for a perpetual lease to the United States of a 6-mile strip along the line of the canal. Thus the way will be cleared for direct action by Congress looking to the work of construction.

From another point of view, the present Con-

The angle of tangent to cable at center of span with the horizontal will also be reduced to $(\alpha - \beta)$. The force acting on stiffening trusses of each half-span at center of span, due to drop of cables, will therefore be the force P which corresponds to angle $\alpha \times \frac{\tan(\alpha - \beta)}{\tan \alpha}$.

The temperature stresses will be reduced by the bending of stiffening trusses produced by them in about the same ratio as the force acting on stiffening trusses at center of span. Since the curvature of cables is nearly uniformly increased over the half-span, the suspender pulls will still be practically uniform over it. The correction here made is not exact, but closely approximate.

The value of s in above formulas can only be ascertained after the general dimensions and the sections of the chords of stiffening trusses are determined.

To ascertain the amount of the temperature stresses in stiffening trusses with three hinges and the amount of the correction due to deflection, a concrete example will now be taken.

We take:

$l = 2{,}800$ ft.; $d = 140$ ft.;
$w = 38{,}000$ lbs.; $\delta = 3.7$ ft.
$h = 350$ ft.;

We obtain:

$$T = \frac{w\,\delta}{h} = 38{,}000 \times \frac{3.7}{350} = 402.$$

If there are two stiffening trusses, the force due to change of temperature acting on each will be $\frac{T}{2}$ per lineal foot. This force will act downward for a rise, and upward for a fall of temperature.

The stress produced in chords at center of the half-span is,

$$S = \frac{T\,l^2}{64\,d} = \frac{201 \times 2{,}800^2}{64 \times 140} = 175{,}875.$$

The $w = 38{,}000$ lbs. includes a dead load of 30,000 lbs. and two-thirds the live load of 12,000 lbs. per foot. The stiffening trusses of such a bridge would have chord sections of about 350 sq. ins., at center of half-spans. The stress per square inch in chords would therefore be

$$s = \frac{175{,}875}{350} = 502 \text{ lbs.}$$

The deflection at center of half-span would be

$$\eta = \frac{2{,}800^2 \times 502 \times 144}{16 \times 29{,}000{,}000 \times 140 \times 12} = 0.72\text{-in.}$$

It is more nearly correct to assume the stress per square inch in chords produced by temperature changes uniform over the whole length of span, than to take the moment of inertia uniform. The latter is far from true, while the former is approximately so. The deflection formulas based on a circular deflection are therefore preferable to those based on a uniform moment of inertia. We find from the above assumed dimensions and weights:

$$\tan \alpha = \frac{2\,\delta}{l} = \frac{7.4}{2{,}800} = 0.00264.$$

By the deflection of stiffening trusses the angle α is reduced by an angle β where

$$\tan \beta = \frac{0.72 \times 2}{700 \times 12} = 0.000171.$$

β is the angle formed by the tangent to center line of stiffening truss at center of span with the straight line which would be the center line of truss if it were rigid. We obtain from above

$$\tan(\alpha - \beta) = 0.00264 - 0.00017 = 0.00247.$$

The corrected force acting on the stiffening trusses of one half-span at center of span is approximately the former force

$$P \times \frac{0.00247}{0.00264} = 0.94\ P.$$

The temperature stresses given by the formula which was derived by neglecting the bending of stiffening trusses are therefore, in the case in hand, about 6% too large.

The drop of 3.7 ft. at center of span due to rise of temperature, from mean to maximum, and the equal rise due to a fall of temperature, are not the only causes of changes in elevation of cables at center of span and of consequent stresses in stiffening trusses. The variation in amount and position of moving load is another cause. For the calculation of sections of stiffening trusses we want, not the largest stresses due to change in elevation of center of span, but those which coincide with the largest stresses in stiffening trusses due to moving load. The latter occur when from one-third to two-thirds of the span is loaded. We need, therefore, to consider only those changes in elevation of center of span which are due to the change of moving load from a maximum load covering one-third to one covering two-thirds of the span. The change of elevation due to this difference in moving load should be added to the change of elevation due to changes of temperature. The stresses should be calculated for half the total change of elevation at center of span, and for a value of w equal to the dead load plus two-thirds the moving load per foot of bridge, since this is the largest load coinciding with maximum stresses in stiffening trusses. The cables should be so adjusted that they form one parabola from end to end of span at the mean dip. Then the temperature stresses are in every member equal amounts of compression and tension.

The general dimensions and loads assumed in the example are approximately those of an actual design. If the changes in elevation of center of span due to changes of moving load are taken into consideration, δ becomes slightly larger than assumed, but the total stresses in stiffening trusses due to the change of elevation of center of span remain below 4% of the stresses due to moving load. The correction due to consideration of flexibility of stiffening trusses amounts to about ¼% of the stresses from moving load. It may therefore well be neglected with high stiffening trusses.

According to Mr. Lindenthal and Professor Melan, the deflection of stiffening trusses at center of half-span due to change of temperature from mean to maximum, would be ¼ of 3.7 ft., or 11.1 ins., instead of 0.72-in., and the temperature stresses would be $\frac{11.1}{0.72} = 15.4$ times as large as calculated by me.

I believe it is evident to any one who carefully follows this argument, that the statements made by Mr. Lindenthal asserting the absence of end reactions, except for unequally distributed moving loads, are not self-evident. They are only rough approximations to the truth.

With three-hinged stiffening trusses, the end reactions due to the total change in length of cables from mean to maximum amount to about 4% of the largest end reactions produced by unequally distributed moving load. The change in length of cables is due partly to change of temperature, and partly to change of tension in them. It is assumed that the bridge is so adjusted that the end reactions are 0 with mean temperature and mean load.

If there is no center hinge, these end reactions due to change in length of cables are evidently very much larger than with a center hinge, other things remaining the same. Any formulas for the calculation of stiffening trusses without center hinges which neglect these end reactions are therefore grossly misleading, unless the stiffening trusses are very shallow. If their depth is only about $^1/_{100}$ of the span then such formulas becomes more nearly correct.

Mr. Lindenthal states in his letter of Oct. 24 that one of the aims in strengthening the Brooklyn Bridge must be greater rigidity vertically and horizontally. The inference from this that he believes the existing stiffening trusses not rigid enough, seems natural, and we thought if justified. In the same letter he seems to doubt that the anchorage bents in shore spans have been suggested before he introduced this feature in some of his designs. In Colonel Roebling's report of January, 1882, the statement is made that an early design with anchorage bents in shore spans had been proposed for the Brooklyn Bridge.

I entirely agree with Mr. Lindenthal that the subject of strengthening the Brooklyn Bridge needs much more study than it has yet received before a definite recommendation in regard to it can be made. The recommendations made in the recent report on the Brooklyn Bridge are too general to allow, without protracted study based on more complete plans of the present structure, a positive judgment as to their adequacy and practicability. Complete strain sheets and general plans of the strengthened structure would be needed to clearly prove that a perfectly safe bridge can be created by the means suggested in the recent report. After Mr. Lindenthal's last remarks on the present stiffening trusses of the Brooklyn Bridge, there remains very little difference between his positive views on this subject and those expressed in the recent report. The purpose of the recent report was to ascertain whether the bridge is safe, and who is responsible for its defects. The proper remedy for the existing defects was only incidentally suggested in it, and could not be exhaustively treated in the limited time available.

Joseph Mayer.

No. 1 Broadway, New York, Dec. 3, 1901.

Mr. Fteley's Reply to the Experts' Report on New Croton Dam and Jerome Park Reservoir.

Sir: In your issue of November 28 you publish the Report of a Board of Engineering Experts to the Aqueduct Commissioners, in which they criticise the plans of parts of the New Croton Dam and of Jerome Park Reservoir, and present especially decided objections to the former.

THE NEW CROTON DAM.

The dam is sufficiently described in the beginning of the report; the side hill overflow and the heavy body of masonry forming the central body of the dam, although the latter is of unprecedented height, appear to meet with their approval, their objection being limited to the southern end, which is formed of an earth embankment with a heavy core-wall.

I do not think that the report gives an exact idea of the existing conditions at that point. The side hill on which the embankment is to be built is formed of extremely compact material, the character of which may be understood from the fact that the deep trench in which the lower part of the core-wall is built was sunken down, with vertical sides, without the slightest indication of any pressure or movement in the surrounding earth, although in view of possible motion of the material, it was thoroughly supported and braced with heavy timber work.

In instances of this kind, when a rock foundation is found within accessible distance under the central part of a dam, it is very usual to abandon the rock foundation and to let the foot of the core-wall step up into the earthy materials of the side hill; such is the mode of construction adopted for the terminal embankments of the Titicus Dam, for the western embankment of Bog Brook Dam, for the embankments of the Main Carmel Dam and of many others. In the present case, however, the core-wall was extended down to the underlying rock into which a deep trench was excavated to receive the foot of the wall. This arrangement presents the additional advantage of establishing the high wall on an unyielding foundation.

At the southern end of the central body of masonry where the embankment begins, the height of the surface of the side hill originally stood at an elevation of less than 60 ft. below the higher water mark of the reservoir; from that point south this depth gradually diminishes down to nothing. A large excavation has been made in the side hill to accommodate the earth cones of the pits necessary for the construction of the masonry dam and of the wing-wall; these pits are obviously to be refilled and it is through them that the large section, Fig. 2, of the report is made. I contend that this section does not give a true idea of the real condition of things. To begin with, why did not the experts show on the plan, Fig. 1, the location of their "line of least resistance"? The report (see the accompanying illustration—Fig. 1 shows that this line, developed on Fig. 1 (in our issue of Nov. 28—Ed.) is as here represented in heavy dash and dot lines on the experts' plan at A, B, C, D.* To many who will form an opinion, possibly without reading the report carefully, the profile, Fig. 2, will convey an idea very different from what the facts would warrant.

I may here point to the fact that, when building Titicus Dam, an extensive earth excavation was also made into the side hill on the north side of the masonry section in order to establish its footing and that of the adjacent core-wall on the rock foundation and, if a section of the structure were made on a similar "line of least resistance" it would show the core-wall with earth embankments on each side, on a minimum slope of 1¾ to 1 with a height of 100 ft. A profile made on this "line of least resistance" at Titicus Dam, in juxtaposition to profile No. 2, would show a result in favor of the New Croton Dam.

Let us consider the two embankments of the dam separately, as they are called upon to act in a very different manner.

The up-stream embankment will be in the water, and the lower and larger part of it will repose, not against the core-wall, but against the main dam from A to B (see plan herewith). When fluctuations occur in the reservoir, they will be so slow, on account of its vast area, that it may be said that no water will flow through the bank with sufficient velocity to displace any particles of earth; the only conditions left to be fulfilled are, consequently, that the embankment will be sufficiently water tight, and that it will not slough off or be washed off on the surface; the last condition will be met by covering the slopes as shown in the plans and specifications, with a layer of broken stone with heavy paving upon it.

As to the condition of water tightness, it is sufficiently met, in my opinion, by the character of the materials to be used, which I have observed continuously for several years while refilling the excavation for the main dam.

The up-stream bank of Titicus Dam, which is nearly 100 ft. high, with a similar slope, was built with materials finer than those used at Croton Dam, and, barring a slow and perfectly regular vertical settlement, which was expected, has acted in a very successful manner. For several years, whenever the height of the reservoir permitted, exact measurements were taken and the slope has never shown any mark of disturbance.

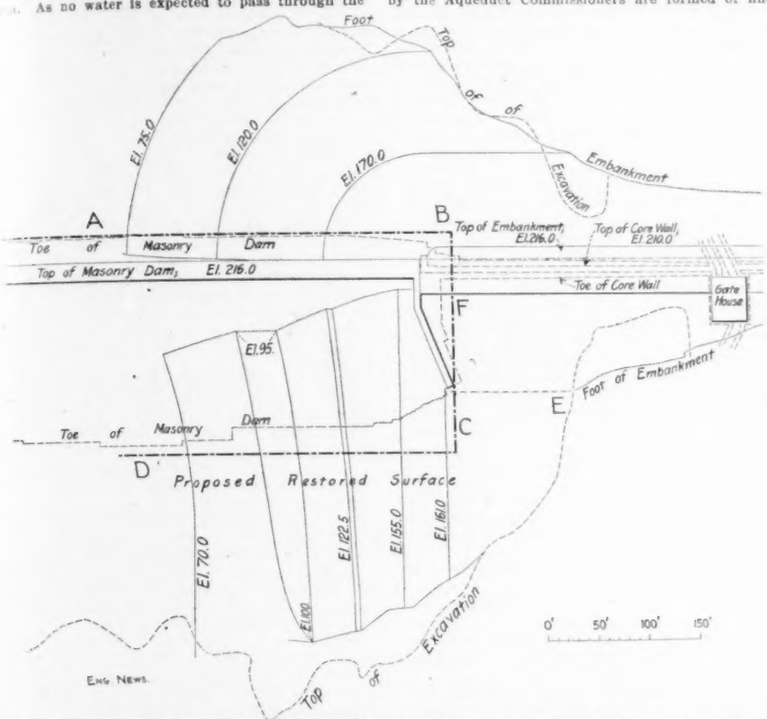
Before construction, both at Titicus and at Croton Dam, earth excavated from the places where it was expected to take it for refilling, was dumped in the stream, care being taken to form the dumps of the finest materials. In no case did those dumps, left unprotected, show a slope steeper than 1½ to 1. A bank, standing at repose in water, cannot be compared to such hill sides as the experts have observed in the valley where they were acted upon by ground water; if their comparison in that respect were correct, no slope of any kind would be practicable, and not an embankment of the dams built in the Croton Valley and elsewhere, under similar circumstances, would remain standing.

As to the resistance of such an embankment to the percolation of water, it is obvious that absolute water tightness cannot be expected; and the experiments made at the Cornell Hydraulic Laboratory only illustrate that point; at any rate, it cannot be expected that the results of laboratory tests, on very small volumes of materials collected on the ground, can throw any valuable light on the ultimate behavior of an extensive bank through which the water would have to percolate for a considerable distance before reaching the masonry parts of the structure.

*We fear that the omission of this line was our own, rather than the fault of the experts. In reproducing the plan we omitted certain reference letters, the object of which was not absolutely clear.—Ed.

Adequate knowledge of the materials used or to be used, and experience, must be depended upon to pass judgment on these matters; moreover, a comparison with the results obtained in the case of the dams built in other parts of the valley show that sufficient water tightness can be confidently expected from the proposed embankment.

The conditions under which the down-stream embankment will have to perform its functions would be entirely different. Nothing need be said of the water that may enter the bank from springs in the side hill or from the rain; the conditions in that respect will be the same as have always existed, with the difference that the turf on the surface will shed the greater part of the rain. There remains the water which will find its way through the masonry or through supposed deep fissures in the rock formation. As no water is expected to pass through the central body of masonry, the surface to be considered is limited to that part of the core-wall adjacent to the refilling of the excavations or to the embankment. What amount of water can find its way through the wall at that point can be appreciated from a comparison with the other dams mentioned in the report and from the comparative thickness of the masonry. In the majority of the cases referred to, the walls are of less thickness, and although the lower embankment will contain, as must be expected, a certain amount of water, the tests made by the experts indicate that a very small volume of it will flow through the wall. At Titicus Dam, where the wall has more thickness, the indications are that very little, if any, water finds its way through it; in the present case the wall for the greater part of its height, at the points where the pressure is highest, is 18 ft. in thickness and built of excellent masonry. From these considerations the conclusion is consistently reached that, in view of the character of the up-stream bank and of the core-wall, a very small amount of water will reach the down-stream bank from those sources.



PLAN OF SOUTH END OF NEW CROTON DAM, SHOWING JUNCTION OF EARTH DAM WITH MASONRY DAM.

(Reproduced from our issue of Nov. 28, with "Line of Least Resistance" added.)

As to subterranean fissures becoming possible channels for the conveyance of water under the proposed embankment, on the ground that eroded fissures have been found under the surface in the bottom of the rock excavation, none of these erosions have been disclosed on the side hill, where the rock has been found uniformly solid and compact; if such seams existed on the side hill, the deep pits excavated for the masonry would have disclosed them, as the water contained in the fissures that were discovered flowed under high pressure, showing that they were fed from distant and high sources.

The experts show a certain "line of bank saturation" as that likely to obtain in the present case. They base their statement on the observations taken by them at the various dams built in the Croton Valley; they find that the maximum safe height of an earth embankment with slopes of 2 to 1 would be "on the bases of the loss of head and saturation at Middle Branch, 63 ft.; Bog Brook, 100.6 ft.; Titicus, 82.3 ft.; Amawalk, 72 ft.; Carmel Main Dam, 102.5 ft." I fail to understand on what basis they state that from their observations the high embankment adjacent to the masonry dam would nearly approach the Middle Branch rate; such a conclusion would presuppose a complete knowledge of the comparative materials used, of the quality of workmanship, and of the various conditions existing during construction, which cannot now be obtained, as the Middle Branch Dam was built more than twenty years ago.

When stating that the saturation of the embankments is not as complete as may be expected in a few years, the experts do not take into consideration the fact that the height of water in the reservoir will vary greatly and that, after each lowering of the surface, conditions very similar to those existing after construction will be reproduced from year to year.

The lower embankments of the dams built in the valley by the Aqueduct Commissioners are formed of fine materials; to that fact is due the elevation of the water slope found in the lower embankment.

Titicus Dam, with its high embankment and its heavy core-wall, is the structure to which can be best compared the New Croton Dam in several respects, and the experiments show that very little water, if any, finds its way through the core-wall, the water in the outer embankment standing 40 ft. below the reservoir level. A similar result is expected in the present case, and should a small amount of water find its way through the wall, the lower embankment, which is to be formed of comparatively porous materials, would allow of sufficient drainage, inasmuch as (to quote from the expert's report), "the slope of the surface of the saturated earth in the bank is determined by the solidity of the embankment."

The Auxiliary Carmel and Titicus Dams show very favorable results, although the lower banks were formed of fine materials, none others being found within reach; with comparatively porous materials they would have shown steeper slopes of saturation. I cannot see the truth of the statement that "the more compact the material of which the bank is built, the steeper will be the slope of saturation." With compact material, the sectional area of flow is larger below a given level than with porous material, and as the bank slope is one determining factor of the line of saturation, this line tends to approach the slope line. With porous material in a down-stream bank the slope of saturation is steeper and the area of flow less. Unless the water finds its outlet on the face of the slope of the embankment, the slope of saturation will also be regulated by the fact that it will reach the ground-water level at a point near the toe of the slope.

At the New Croton Dam, the down-stream bank has a 2 to 1 slope for a depth of about 60 ft. below high-water mark, and the unusual width of the top of the embankment is equivalent to a flattening of the slope. Below this, the retaining slope along the down-stream face of the main dam (on the "line of least resistance") has a general inclination of nearly 3 to 1.

No better evidence can be given of the stability of the lower embankment than the manner in which the slopes of the excavations have stood during the prosecution of the work, although acted upon by the water coming from the ground behind them and by the rains of many seasons. In the center of the valley, where the ground water was more abundant and the material less compact, the slopes remained on an average of 1½ to 1. On the side hill, the hardpan forming the mass of the earthy material above the rock and against the face of which the refilling and embankment at the south end of the New Croton Dam are to be made, has stood for several years at an excavated slope of ½ to 1 for a depth, at the lowest point, of over 100 ft., above which was a flatter slope of sand and gravel of an additional 50 ft. in height, thus forming a total height of slope of 150 ft. The slope flaked off in cold weather only, and only with successive freezing and thawing, when the thickness of the flake was that of the depth to which the last preceding frost had penetrated, the slope practically keeping its inclination. This hardpan had to be loosened by blasting, both in the excavation for the main dam pit and the core-wall trench; it was too hard to handle by any ordinary means.

The experts suggest that the alleged lack of stability would be, to a large extent, overcome by flattening the embankment or by facing the lower slope with a revetment of heavy stone paving; these two suggested additions are, in my opinion, unnecessary; if I were to suggest an improvement to the present plan, I would recommend the drainage of the lower parts of the embankment; this work could be done on an extensive scale, at a comparatively trifling cost, with excellent results.

The experts object to the original plan of the dam, which they call unjudiciously designed, on the grounds that no provision had been made to meet the contingency of a sudden and exceptional flow of water due to a cloudburst or to other causes. The fact is that the original design was especially devised to meet that condition. Although the surface of the reservoir, covering thousands of acres, is so large that it would have a great equalizing power, the contingency of a sudden flood causing the overtopping of the masonry dam was carefully considered. To that effect, the top of the embankment was kept much above the crest of the masonry and a large amount of rock from the excavations was ordered to be placed on the top of the filling, below the dam, to prevent a harmful disturbance of the surface. The contract drawings are not at hand, but it is well understood that they are of a general character and cannot be expected to show all the details of the work, but the connection of the top of the embankment with the crest of the dam is shown on Sheet 22 of the Report of the Aqueduct Commissioners of Jan. 1, 1897, and the necessary orders for the performance of the work were given.

I learn by the report of the experts that changes have recently been made, one being the raising of the crest of the masonry dam. The reasons for that change in the plan are unknown to me. I agree that it is injudicious, as it destroys a feature which was considered very important. The calculations for the stability of the dam were made in view of the original elevation of the crest.

As to the statement that the architectural appearance of the dam is marred by the composite plan, I beg to differ from the experts; the abutment of the heavy masonry, at a point where it presents a considerable height against a massive wing-wall of similar construction is, in my opinion, a more satisfactory solution of the problem; Titicus Dam and the Main Carmel Dam, for instance, are built on that plan and both structures present architectural features which have met general approval.

The "impression" that the present plan has the appearance of "a parsimonious makeshift not in harmony with the central portion of the dam" may have been produced on the experts; I trust that the general beholder would not be impressed in the same manner; but when they inquire why so great an expenditure has been made "on the ornamentation and architectural appearance of the central portion of the dam" (referring, I suppose to the treatment of the cornice work, because the rest of the masonry shows none but essential features), they forget that while the cost of that work does not represent a tithe of the additional expenditure which they recommend, it is conducive to the architectural effect that they express their desire to find in the structure.

Economy of design, when properly applied, is one of the main principles of engineering; it was undoubtedly given due weight in this instance, and it should not be departed from without the clearest demonstration that the proposed change is a necessity. It is not thought that the experts' arguments would produce that conviction on those experienced in the construction and maintenance of earth dams, and their determination of a probable line of saturation does not appear to be logically deduced form their observations of existing dams, or to be based on a sufficient study of the mode of percolation of water through fine materials.

JEROME PARK RESERVOIR.

The instructions given to the experts limited their examinations to the embankments south and east of Jerome Park Reservoir on a length of several thousand feet.

Their report gives a detailed description of the grounds on which the embankments are partially erected.

The depth of water is to be from 23 to 26 ft.; the top of the embankments about 6 ft. above high-water mark. At places, the rock underlies the natural surface at vari-

ous depths; the materials above it are composed of sand, mostly quite fine; outside of the embankments, the natural surface or the filling which has taken place since construction was begun, stands at one point as high as the high-water mark, and, elsewhere, at elevations varying all the way to a maximum of 10 or 12 ft. The section of the outer embankment can consequently be described as being formed of an upper part, a few feet high, with a slope of 2 to 1; the lower part presenting such flat slopes that they extend hundreds of feet from the reservoir before reaching the elevation of its bottom. The conditions of stability are consequently exceptionally good.

The inner slopes of the reservoir are built at the rate of 2 to 1. They are to be lined with concrete on which a paving partly of brick, partly of stone, is to be laid. The bottom of the reservoir is also to be covered with concrete.

Considering the moderate depth of water in the reservoir, the nature of the materials to be used, and the exceptionally stable character of the outer part of the embankment, it might have been questioned whether any additional protection were necessary; there is no lack of precedents for such a mode of bank protection for reservoirs presenting an even greater depth of water with less substantial embankments. Jerome Park Reservoir, however, being situated in the middle of a district which will be densely populated and where the land is very valuable, it was thought that no precaution should be neglected, not only to render the structure perfectly safe, but to avoid any percolation of water which would cause damage and annoyance to the surrounding land owners. It was consequently decided to add to the water tightness of the embankments by building core-walls in their center. Wherever the rock was at a short distance from the surface, the walls were built down to it; in other places the foundation was placed at from 8 to 10 ft. below the bottom of the reservoir; in the latter case they were generally built on sand which, under the conditions in which the walls are placed, furnish a very acceptable foundation.

From what precedes it can be seen that the embankments examined by the experts are of exceptional stability. From personal observation during construction I am convinced that the water tightness will be all that can be desired.

In the presence of such exceptional circumstances, I fail to see on what grounds the experts can recommend a change of the inner slopes of 2 to 1 to 2½ to 1.

As to their recommendation that, at the intersection of the slopes with the reservoir bottom, the interior lining of concrete should be made double the thickness that is provided in the plans, I can only say that it has been anticipated in the instructions given to the engineer in charge to recommend at those points such concrete toe as should be found adequate to the necessities of each case.

It is to be regretted that the instructions given to the experts were limited to the aforesaid embankments, as changes have been introduced and are now being made at other points without necessity and to the detriment of the general design.

Along Sedgwick Ave., where, owing to the heavy adjacent slope of the ground towards Harlem River, percolations through the seams of the underlying rock must be especially avoided, an embankment similar to those described above had been designed and a deep sewer had been provided in the avenue to cut off such water as could escape. As the surface of the avenue is only 10 to 12 ft. below high-water mark in the reservoir, the stability of the embankment was beyond question.

The plan has been changed to a heavy masonry wall and present indications point to the abandonment of the sewer. This wall has been built on a line about 2,500 ft. long and is to be continued to an extent not known to the writer.

By this change, the stability of the structure has not been improved, the chances of percolation have been increased, and a very large unnecessary expenditure has been incurred.

New York, Dec. 7, 1901. A. Fteley.

Notes and Queries.

E. W. M., Greensboro, N.C., calls our attention to two typographical errors in Mr. Gillette's article on "Estimating the Cost of Concrete," p. 423, of our issue of Dec. 5. In the formula in the middle column for N (number of barrels of cement per cubic yard of concrete) the last term of the divisor should read: $(1 - 0.8\ V)\ y$. Also at the bottom of the last column, where numerical values are introduced, the figure 5 was omitted as a multiplier of the last term of the divisor. The editor may add that both the omission of the minus sign and of the figure were apparently due to their dropping out of the forms after the final proofs had been passed by editors and author.

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The 44th meeting of the American Society of Mechanical Engineers was held at the house of the society, in New York city, on Tuesday, Wednsday, Thursday and Friday, Dec. 3 to 6. The meeting was opened at 9 o'clock Tuesday evening by the address of the President, Mr. S. T. Wellman, of Cleveland. His subject was "The Early History of Open-Hearth Steel Manufacture in the United States." The address is printed nearly in full in another part of this issue.

The active work of the meeting began at 10 a. m. on Wednesday, when the annual business meeting of the society was held.

BUSINESS MEETING.

The first business was the report of the tellers on the letter ballot for election of officers. The regular nominees were elected without opposition as follows: President, Edwin Reynolds, Milwaukee; Treasurer, Wm. H. Wiley, New York; Vice-Presidents, Wilfred Lewis, Philadelphia; M. E. Cooley, Ann Arbor; M. P. Higgins, Worcester; Managers, R. S. Moore, San Francisco; H. A. Gillis, Richmond; C. H. Corbett, Brooklyn.

The annual report of the council was then read by the secretary. The report announced the appointment of an additional assistant to the secretary in the person of Mr. Arthur L. Rice. An amendment to the rules to make more than seven negative votes necessary to defeat a candidate for membership is under consideration. Boston has been selected as the place for holding the spring meeting of 1902. The total membership of the society is now 2,329, of which 537 are in the junior grade. The report of the finance committee showed total receipts of $42,558 and total disbursements of $36,493 for regular expenses and $5,188 for unusual expenses. It appeared, however, that this is merely a cash account and that the publication expenses are much larger than are shown in the report, because the society has been running in debt to its printers. A large part of the report was taken up with a discussion of the society's financial condition, and with a reprint of the circulars respecting the increase of dues which have been issued to the members.

THE PROPOSED INCREASE OF DUES.

Next in order came action on the amendment to the society's "Rules," of which notice was given at the Milwaukee meeting, raising the annual dues to $25 for members and $15 for juniors. An exciting debate at once started on this question and continued for nearly three hours before a ballot was finally ordered. Limitations of space permit only the briefest outline of the debate to be presented here.

The formal motion for the adoption of the amendment was made by Past-President R. W. Hunt, and he coupled it with the surprising announcement that the society is now about $13,000 in debt, its expenses having exceeded its income for four years past until a deficit of the above amount has accumulated. He declared that the council had considered and adopted every possible measure of economy and found that they would only effect a total reduction in the running expenses of about $4,000, or little more than enough to bring the expenses within the income, while providing nothing for paying off the debt. He appealed to the loyalty of the members to support the amendment.

Mr. F. H. Boyer, of the council, in seconding the amendment, displayed great indignation at the technical press for giving publicity to the proposed increase of dues. He declared that it was intended to keep the matter as quiet as possible until the members came together at the annual meeting. He made also the surprising admission that two-thirds of the council members came to the council meeting on Oct. 31 strongly opposed to the increase of dues and were there converted by the arguments of one of the society's past-presidents.

Mr. H. R. Towne, of the council, said that while he had joined in supporting the amendment, he now felt that it called for too great an increase in the dues. It would give the society an added income of $18,500 a year, whereas the net debt (deducting collectible dues) is only $10,000. Thus the debt would be provided for in a short time and the society would thereafter have an annual surplus of about $16,000. He thought action on the increase should be postponed and a smaller increase should be made, say $20 for members and $12.50 for juniors. He admitted that the council was seriously at fault in allowing the society to run into debt, but declared that until the council meeting of Oct. 31, two-thirds of the council members knew nothing of the debt's existence.

Mr. E. D. Meier censured the council for not giving the members full information as to the society's finances at the same time that it proposed the increase of dues. The opposition to the increase was entirely justified by the fact that the council withheld this information.

Mr. W. S. Rogers opposed particularly the increase of dues of the juniors who have no vote, and were to be held up for an additional $5 per year, which many of them could ill afford. He urged economy in the administration of the society as the proper remedy for its financial difficulty.

Mr. Angus Sinclair said the only sound rule for a society like an individual was to keep its expenses within its income. The council ought to have known that a contrary course had been pursued during the past four years. Its plea of ignorance was no excuse.

Past-President W. R. Warner, thought no one should object to paying such trifling dues as $25 a year when the benefits he received from the society were so great. The proposed increase amounted to only 3 cts. a day; less than the cost of a cigar. He hoped to see the day when the dues would be raised to $50.

A member (whose name our reporter failed to note) said engineers were frequently called in for advice when a manufacturing concern is in financial difficulties. What engineer in such a case would adopt the policy of increasing the price of goods to its customers?

Mr. John R. Platt corrected the misstatement in the official circular comparing the dues of the American Society of Civil Engineers and this society's. The Institute members pay dues which are less on the average than this society, and receive four large volumes a year of transactions.

Mr. M. N. Forney said he held over 100 proxies of absent members, instructing him to vote against the increase of dues. He favored the appointment of an investigating committee to examine the society's financial condition and its business methods.

Mr. Halsey said that it was a fortunate thing for the society that the technical press had given full publicity to the proposed increase of dues and enabled absent members to vote by proxy. The tone of numerous letters received from absent members showed that had the council carried out its intention and had the proposed increase been adopted by vote of members present at the annual meeting, it would have disrupted the society.

Mr. Geo. L. Fowler told of the numerous letters he had received in opposition to the increase. Many of them were from men entirely able and willing to pay the increase themselves, if the interests of the society really required it.

Mr. Gus C. Henning urged that the society should remodel its methods on the pattern of the German Society of Engineers. The dues in that society are but $5 and there are 16,000 members. He proposed to offer later a new set of rules for the council's consideration to enable these methods to be adopted in the American society.

Mr. R. H. Soule said that although he, as a member of the council, had signed the circular favoring the increase of dues, his support of the measure had never been more than half-hearted, and he was now in grave doubt as to its wisdom.

Mr. Geo. S. Morison said that the present dues are as large as those of any other engineering society. To increase them beyond this point was a step which should only be taken after most careful consideration. The American Society of Civil Engineers, with $15 dues, holds fortnightly meetings, publishes both advance papers and complete transactions and gives its members a very large return for their money.

Mr. Wm. Kent severely criticised the form in which the financial reports of the society are presented. The alleged balance sheet contains a statement of assets but no statement of liabilities. Nominally, according to the report, the society has about $80,000 of assets, and never, even in the present year's report, is any detailed statement of the society's liabilities presented.

The above gives a fair idea of the general tone of the discussion, which was participated in also by several members besides those we have named. By this time the desire of the meeting that the matter be brought to vote became increasingly evident. Mr. H. R. Towne made a motion to have the matter tabled, so that it might be brought up for action at some future time. The opposition of the meeting to this course, however, was evident, and numerous holders of proxies announced their intention to cast them against such a disposition of the matter. The motion was therefore withdrawn and a vote by ballot on the adoption or rejection of the increased dues proposition began, a recess for luncheon being taken during the balloting. As several hundred proxy votes were cast, the counting of the vote was a slow process and the final result was not announced till the session on Thursday morning. It was as follows: Total ballots cast, 874; ayes, 191; noes, 647; irregular, 36.

At 3 p. m. the meting was again called to order for the transaction of further business. Mr. Gus. C. Henning offered a set of amendments to the society's rules to provide for certain radical changes in the conduct of its affairs on similar lines to those followed in the German Society of Engineers. He submitted them for consideration by the council and for final action by the society at the annual meeting a year hence.

A resolution was offered by Mr. Rogers, providing for the appointment by the council of a special committee of five members, not now holding office, to make a detailed investigation of the society's condition, its methods of carrying on its work, and any causes for dissatisfaction among the membership at large which may exist. Past-President H. R. Towne stated that the council, at a meeting on Dec. 3, had taken substantially the action which the resolution called for. After some discussion a motion was carried that any action by the society on the matter be postponed.

Mr. Charles Whiting Baker gave notice of an amendment to the society's rules which will require future amendments of these rules to be submitted to a letter ballot. He urged that the cumbrous system of proxy voting which had consumed so much time at the present meeting would be unnecessary if the letter ballot were established. The proposed amendment allows any member to offer an amendment to the rules at any regular meeting of the society and such amendment may be taken up at a succeeding session for discussion, alteration and final rejection or approval by majority vote of those present and voting. If approved, it is then to be submitted to a letter ballot of the entire membership and is adopted if favored by a majority vote. Mr. Baker asked to have those pre-

ent discuss and criticise his proposed amendment and that the meeting indicate its approval or disapproval. After some discussion it was voted to approve the amendment. This concluded the business session, and the formal exercises for the day.

TECHNICAL SESSIONS.

On Thursday morning, the society took up the topical discussions that had been slated for Wednesday morning. The first of these was on the "Cost of Running Trains at High Speed," the subject having been suggested to this society by the Western Railway Club. (See the papers on this subject by J. G. Crawford in Engineering News of Sept. 12 and Oct. 31 last.) In the discussion, Mr. Lewis asked where the formula $R = \frac{V}{6} + 3$ was obtained; Mr. Geo. L. Fowler stated that this "Baldwin" formula for train resistance was derived from a long series of tests between Camden and Philadelphia over the tracks of the Philadelphia & Reading Ry.; the formula give results closely similar to those obtained by the Engineering News formula, first worked out by Mr. A. M. Wellington, and that both formulas gave lower results than the Clark formula referred to by another speaker. The further discussion brought out the desirability of knowing economic speeds of freight trains in connection with the subject under discussion; the relative decrease of the item of train service at high speeds; the fact that in tests on the Chicago, Milwaukee & St. Paul Ry. the only increased item for increased speeds was that of fuel consumption, this increase being 14% for a speed increase of 25%.

The second topical subject was "Some Peculiarities of Springs," introduced by Mr. Stephen W. Baldwin. The speaker stated that while coil springs were more sensitive and durable, they did not kill rapidly enough the oscillation set up by a blow coming on them, whereas flat or leaf springs, by the frictions between the leaves, caused these oscillations to disappear quite rapidly. A machine had been rigged up to record spring oscillations, consisting of a pencil moved by the spring to be tested over a strip of paper in a vertical direction, the paper being given a uniform horizontal motion. The curves obtained were the records of the oscillations, and showed how these died out very gradually with coil springs, and very rapidly with leaf springs. This recording device had suggested to him the possibility of using records so obtained to judge of the relative adaptability of any particular steel for spring making, especially since fatigue of the spring would show in the altered form of the diagram.

Mr. A. Cary referred to the effect on the spring's action of imperfect support of ends, eccentric loading, friction losses in cup ends, etc.; he claimed that differences in temper had no influence on the modulus of elasticity. A steel of higher temper had merely a higher elastic limit and the elastic oscillations of the spring would therefore not be affected. Basing on his former experience in spring making, he asserted that coil springs when properly made are uniformly highly reliable and durable, whereas leaf springs give much trouble from wearing out. He described different devices that have been used to reduce the range of vibration in coil springs, such as secondary springs, rubber intermediate layers, dash pots (as in door checks), etc.

The third topical subject, "The Linvolpon System," elicited no discussion.

A PORTABLE ACCELEROMETER FOR RAILWAY TESTING.

This paper of Mr. F. B. Corey, who is connected with the Schenectady Works of the General Electric Co., was read by Secretary Hutton in the author's absence. The substance of the paper is given in the following:

In all railway work the all-important factor to be considered is speed, and it is often necessary to secure accurate data in regard to the rate at which the speed changes under various conditions of equipment and operation. To obtain the desired information from a continuous speed record is generally unsatisfactory, and various devices have from time to time been tried in order to secure direct readings of acceleration and retardation.

The following seems to be the requirements to be met by a practical instrument of this class: (a) It should have no delicate moving parts. (b) It should be susceptible of accurate calibration, and this calibration should be permament. (c) The reading scale should be sufficiently extended to render the readings reasonably accurate. (d) It should be practically "dead-beat" to record rapid fluctuations. (e) It should not require for its operation any mechanical connection with the axle. (f) It should be of such size that it may be readily carried about in small space. (g) It should either be independent of grades or be capable of measuring the degree of inclination, so that its indications may be readily corrected.

In addition to the above requirements, it is extremely desirable that the instrument be such that continuous records may be made, so that we may properly study the various changes of acceleration and retardation throughout any given period of time.

The present instrument is designed to fulfil these requirements as nearly as possible. It consists of a short horizontal passage filled with mercury, with vertical tubes rising at either end and filled with a colored liquid adapted to be read easily. The upper ends of the vertical tubes are connected together to prevent evaporation and spilling. The plane of the two tubes being set in the direction of motion of the car, the acceleration which the latter is subject to will produce a difference of level of the liquid in the two tubes. The vertical tubes are graduated to correspond to such acceleration in miles per hour per second, and also in pounds per ton accelerating force.

It is evident that if the accelerometer be set to the zero position when the car is either at rest or moving uniformly on either a level or gradient, the indications will be accurate only so long as the car remains on track of constant grade. When the grade changes, the accelerometer must be readjusted or the proper correction made. Usually either a stop or a period of constant speed running gives opportunity to reset the instrument or determine the correction. When this cannot be done at the time of testing, the accelerometer should be set at zero on a level track, and the car run over the road and brought to rest on all grades to be measured. It is evident that used in this way the instrument becomes a gradiometer, giving an indication of 20 lbs. per ton for every 1% of grade.

Generally a record of the accelerations will be found desirable. For this purpose the instrument is arranged adjacent to a recording drum, the pencil being connected to a pointer moving vertically along the tube of the instrument. The fluctuations of the instrument are followed by hand, the pointer being kept constantly at the level of the liquid.

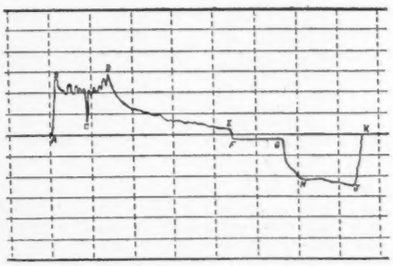


Fig. 1. Record Obtained by Corey Accelerometer.

Fig. 1 is a reproduction of a portion of the record strip of a run with a single car of approximately 40 tons weight, equipped with standard electric train-control apparatus, the part shown representing a short run (between stations) from start to stop. On the vertical scale 1 space represents 50 lbs. per ton effective accelerating force, or .55 mile per hour per second acceleration, while on the horizontal scale 1 space represents a time period of 10 seconds.

The interpretation of this diagram is as follows: Beginning at A, the acceleration rises very rapidly, indicating 1.4 miles per hour per second after an elapsed time of 1.5 seconds. The acceleration rapidly falls off until the master controller is turned to the second notch, when it again rises, the maxima and minima depending largely upon the skill or wishes of the motorman. At C is seen an almost instantaneous drop in acceleration, the curve theoretically touching the base line. This occurs at the point of transition from the series to the parallel motor combination. The error here is due more to inability to follow accurately the sudden fluctuations than to any fault in the operation of the instrument itself. At D the full parallel position is reacned, when the acceleration rapidly falls off until, at E, it has dropped to about .14 mile per hour per second. At this point power was cut off and the acceleration immediately dropped to a negative value of about .13 mile per hour per second, equivalent to a retarding force of about 12 lbs. per ton due to friction. The distance FG represents the time during which the car was allowed to coast freely. At G a service application of the air brakes was made, the retardation rapidly increasing until, at H, the full power of the brakes is applied. From H to J the gradual increase in retardation will be noted, due to the increase in the coefficient of friction with reduction of speed. At J, just before the car came to a full stop, and when the retarding force had reached a maximum of 125 lbs. per ton, the brakes were partially released and the car was brought easily to rest.

If any given acceleration be multiplied by the time during which it is maintained, the product is the resulting increment of speed. It is therefore evident that the integrated area between the acceleration curve and the datum line up to any given ordinate multiplied by a proper constant is the speed of the car at the corresponding instant. This constant, or the speed per unit of area, is equal to the scale of abscissas multiplied by the scale of ordinates. For example, in Fig. 1 the area included between the acceleration curve and the datum line up to the instant at which power was turned off is found to be 0.66 sq. in. Therefore the speed of this car at the instant corresponding to E on the curve was 20 (seconds) multiplied by 2.2 (miles per hour per second) multiplied by 0.66 = 29 miles per hour.* If the speed is to be measured at any instant during retardation, the required area is the algebraic sum of the areas above and below the datum line up to the designated ordinate. Thus, by means of the planimeter, the instantaneous speed of the car may be measured directly from the accelerometer record.

The discussion on this paper brought out the fact that Mr. Don J. Whittemore, of the Chicago, Milwaukee & St. Paul Ry., had described a similar instrument some years ago before the Western Society of Engineers. Mr. Lewis stated that he had himself constructed several years ago an instrument very similar to that of Mr. Corey, and noted that the latter shows no advance over his own instrument. He considers the impracticability of obtaining an autographic record the most serious defect of the device. Mr. Geo. L. Fowler stated that in the course of a series of tests he conducted some years ago he found that any record produced by eye-reading was entirely unreliable as the variations are too rapid to permit of proper following by the eye. The best results he obtained were produced by simultaneous records on the same strip, of ¼-second intervals given by electric contacts in a clock, and axle-revolution records similarly produced by electric contacts on the axle. From such a record any draftsman was able to plot an acceleration curve. Mr. J. A. Brashear stated that an arrangement very much like Mr. Fowler's was used by himself and Professor Langley in their experiments on aerodromics and the flight of birds some years ago. The results were almost perfect. Professor Kingsbury pointed out several faults in Mr. Corey's device, principally that the only way to correct for grade was to know the position of the car on the track at any moment.

*On the original diagram, 1-in. on the vertical scale equalled 2.2 miles per hour per second acceleration and 1-in. on the horizontal scale, 20 seconds.

A BONUS SYSTEM OF REWARDING LABOR.

Mr. H. L. Gantt, of South Bethlehem, Pa., read in abstract his paper on this subject; the essential points of this paper and of the discussion upon it are published separately on another page of this issue. The paper proved to be in many ways the feature of the meeting, and aroused an interest and favorable comment to a degree rarely met with in the society's history. As will be seen from the discussion, the paper was by one member designated as epoch-making, which expressed the sentiment of a large number.

A SILENT CHAIN GEAR.

The paper on this subject by Mr. J. O. Nixon was read by the author. It described the style of chain and sprocket invented by Mr. Hans Renold, of Manchester, England; this system of gearing was described in our issue of Sept. 5, 1901. Mr. Nixon discussed the various questions affecting the use of chain gearing and illustrated the manner in which the Renold system overcomes most of the difficulties urged against chain transmission.

In the discussion following, Mr. G. I. Rockwood corrected a statement which had been made to the effect that the looseness due to wear caused chains used in automobiles to jump their sprockets, by saying that he found in his machine, after much trouble with the chain jumping, that this was caused by wobbling of the gear on the rear axle due to springing of the axle. When the supporting yoke was made sufficiently long to avoid excessive deflection of the axle, any good chain would give practically no trouble from jumping.

THE BURSTING OF SMALL CAST-IRON FLYWHEELS.

The paper that now followed was that of Prof. C. H. Benjamin on "The Bursting of Small Cast-Iron Flywheels," detailing the results of a series of bursting tests of 24-in. cast-iron flywheels of various designs recently carried out by him in the laboratories of the Case Scientific School at Cleveland. The paper is reproduced in part on another page. There was no discussion of the paper, though the members manifested considerable interest in Professor Benjamin's experiments and results.

REPORT OF COMMITTEE ON ENGINE TESTS.

This committee presented a preliminary report, which with the discussions offered at the Milwaukee meeting and the criticisms and suggestions received by the committee since that meeting, covers 88 printed pages. The report was presented to the society by Prof. D. S. Jacobus, who commented on all the points of special interest or of departure from practices hitherto recognized as standard either here or in Europe, and brought out all the main points of criticism contained in the contributed discussions received by the committee.

Following Professor Jacobus, Mr. G. I. Rockwood expressed his regret that the report was not drawn up at least 15 years ago. He considers that most of the engine testing for scientific purposes has already been completed, and thinks it would have been highly advantageous if this accumulated mass of data could all have been arranged in accordance with the methods here presented. He further considers that since engine testing now is largely done for and at the instance of the manufacturer (steam user), who generally wishes to know only certain definite results, that the viewpoint of the manufacturer as also that of the engine builder should be given some consideration in the report.

Mr. Wm. Kent (Assoc. Ed. Eng. News) quite approved of the action of the committee in using the higher heat value of coal (calorimeter value without deducting latent heat of moisure). He also approved the committee's use of the condenser or the atmospheric pressure to give the temperature of the exhaust instead of measuring the temperature in the exhaust pipe.

The work of the committee is not ended with this report, but certain further revisions will be made, and all discussion received up to the time of revision will be duly considered before the final report of the committee will be presented to the society.

COMMITTEE ON STANDARDIZATION OF ENGINES AND DYNAMOS.

The final report on this subject was presented, on behalf of the committee, by Mr. Albert L. Rohrer, who called attention to its leading points of interest. The report considers direct-current engine and dynamo-generating units, and takes up in course, the standard sizes of units, the corresponding revolutions per minute, the sizes of shaft for side and center-crank engines, the length along shaft required for the generator, height of axis above top of sub-base, width of top of sub-base, armature fit (on shaft), overload capacity of engines and generators, brush-holders, holding down bolts, keys and outboard bearings. Seven standard sizes of units are given, up to and including 200 K-W.; revolution speed was carefully chosen and 5% variation above or below average allowed; shaft diameters were calculated for deflection; heights of shafts were chosen to suit both horizontally and vertically split generators; overload capacity was limited to 25%, since the values generally required for dynamos alone would call for excessive engine dimensions; brush-holders

were required to be supported on generator frame; furnishing of miscellaneous parts, such as outboard bearings, shaft-keys, etc., was properly distributed between engine builder and dynamo maker, and a number of other recommendations were made tending to secure uniform and good practice.

Mr. McFarland, member of the committee, called attention to the fact that a number of engine and generator builders had expressed themselves as anxious to know when the report would be adopted by the society, and stated that for this reason he should like to see some action taken on the report. A motion was then carried that the report of the committee be accepted and the committee discharged.

A NEW VALVE GEAR.

This was the first paper taken up by the meeting on Friday morning. In the absence of the author, Mr. E. W. Naylor, the Secretary read the paper by abstract.

The paper treats of an arrangement made by Mr. Naylor for operating the steam and exhaust valves by electro-magnets. He expected thereby to secure admission and cut-off materially sharper than can be obtained by other gear, and to be able to adjust these points much more easily. He applied his method to a 5-HP. single-acting three-cylinder engine. The valves used were poppet valves placed in the cylinder heads; the maximum opening for each valve was $^1/_{32}$ the area of the cylinder. They were operated by levers having on their axis of rotation magnets acted upon by an electro-magnetic field. The current producing this field was controlled by contacts sliding on a rotating disk of copper inlaid in fiber, and the position of these contacts could be varied so as to give changed time of valve opening. Mr. Naylor emphasized the steam economy of his valve gear and the reduction in engine vibration caused by doing away with valve rods, eccentrics, etc. Mr. Naylor had sent in additional manuscript on the recent loss of several English destroyers. In this he brought out that the vibration of the engine's right on the backbone of a structure in itself statically unsafe was probably the cause of their destruction.

In the discussion following, the paper was criticised as incomplete; for instance, in making the statement that cylinder condensation was almost nil in such a way as to imply that this was an effect of the operation of the valve gear, and in omitting to give indicator cards which would be the only evidence that could be adduced as to the actual behavior of the steam under the control of the electrical valve gear.

THE POTTER MESH SEPARATOR AND SUPER-HEATER.

A paper on this subject was read by the author, Mr. F. A. Scheffler. It describes an arrangement used in the boiler in place of a dry pipe to deliver dry steam. This separator consists of a cast-iron case containing a series of sheets of fine wire mesh through which the steam must pass in order to get to the steam main. With a loss in pressure of but 1%, the author stated that practically dry steam is obtained. All foaming and throwing of water is also prevented from producing harmful results.

The discussion of the paper showed much lack of faith among the members in the utility of this device as well as of dry pipes or similar devices generally. A number of members said that well-designed boilers would never prime or throw water; as to the value of this device in superheating the steam, i. e., evaporating the free moisture contained in it, figures were given to show that to produce any practical effect the drop in pressure would have to be far greater than 1%.

In reply to the criticisms, Mr. Scheffler remarked that while a well-designed boiler possibly would never prime, yet few boilers were well-designed, and this device would prove of value in such cases. The word superheater was not to be taken strictly, being used simply to distinguish this device from mechanical separators.

FINAL REPORT OF COMMITTEE ON STANDARD PIPE UNIONS.

Following this, the Committee on Pipe Unions presented its final report, which was read by Mr. Geo. M. Bond, of the committee. The committee in the course of its work critically examined the various standard makes of pipe unions in all details, and found that no one make was satisfactory in all sizes from ⅛-in. to 4 ins.; it therefore becames necessary to design new standard unions. The designs for these standards, after being drawn up with the greatest care, were submitted to a number of makers of unions, with requests for criticisms and suggestions for improvement. From two of these, replies were received, which were carefully considered and which resulted in certain changes in the designs. The corrected designs were again submitted, and no replies being received, it was assumed they proved satisfactory in all respects. Sample malleable iron unions were now made according to these designs and submitted to a variety of tests, direct tension and bending (solid stub ends being screwed into the unions for these purposes) and also a bursting test under hydraulic pressure. All sizes tested showed up well, and nothing was learned in the course of the tests that would suggest further improvement. These designs were therefore submitted to the society as standards; the committee further suggested that the letter S be cast on all unions made in accordance with these standards, and that this designation be copyrighted. Licenses to use this mark S could be issued at nominal figures to manufacturers of unions wishing to make unions in accordance with the standard.

On motion, the report of the committee was accepted by the society.

WORKING LOADS FOR MANILA ROPE.

Mr. C. W. Hunt presented his paper to the society with a few explanatory remarks, calling attention to the fact that it was intended merely to record results of practice.

There was no discussion on the paper. We reprint the paper in full on another page.

THE HEAT-ENGINE PROBLEM.

Mr. C. E. Lucke, a non-member, now read by abstract a paper presented for him by Mr. R. H. Fernald, associate member of the society. The paper dealt at great length with the general problem of the conversion of heat into mechanical energy, and then turned to the consideration of a non-explosive internal combustion engine, operating on what the author called the Brayton cycle. The failure of all previous types of engines attempting to utilize this cycle was examined, and certain experiments made with the object of determining conditions of continuous ignition of a body of gas, a manner of ignition producing in the cylinder practically constant pressure up to a predetermined point of "cut-off." Certain means were found by which ignition of this sort could be obtained, for instance, allowing gas to flow from a tube under a pressure of about ½-lb., and covering the mouth of the tube with a heap of small stones, etc., to keep the flame from traveling away from the tube and "blowing off." Further experiments, using oil as the combustible, were reported as being in progress; the outcome of the whole investigation will probably be the construction of an engine designed to operate in the manner brought out in the paper and on the basis of the results obtained from the experiments.

In the discussion on the paper, the use of the term "Brayton" cycle to designate the operation of an engine such as was aimed at by the author was strongly objected to, on the ground that Brayton's engine operated in a quite different manner. Prof. W. F. M. Goss mentioned that Brayton, when he got up his engine, went through about the same series of experiments as were described in this paper, and that Brayton's conclusions as derived from these experiments found expression in the engine which he constructed and which bore his name. Brayton's engine, Professor Goss continued, has been in the scrap heap now for many years.

In reply to the various criticisms, Mr. Lucke stated that he used the word cycle to express a series of operations gone through by a gas, and this did not necessarily imply a definite construction or method of operation of the engine; two engines may operate in totally dissimilar manner, yet the gas employed in the two cases may go through an ultimately identical series of changes.

EXPERIMENTS ON SPIRAL SPRINGS.

A paper presenting the results of certain experiments on coil springs, made by Mr. R. A. French, of Pittsburg, Pa., a non-member, was presented to the society, and read in abstract by Prof. C. H. Benjamin. The paper is published in full elsewhere in this issue.

In the discussion on the paper, Mr. Wm. Kent (Assoc. Editor, Eng. News) called attention to the range in the values of G, the modulus of torsional elasticity, for which values ranging from 12,500,000 to 18,900,000 lbs. per sq. in. are shown. He reminded the society of the fact that one of the most constant qualities of iron or steel through all changes is its elasticity-modulus for direct stress, which is only less constant than the specific gravity of the metal, and pointed out that the variation of the shearing modulus shown in these experiments would, if verified, certainly constitute a remarkable phenomenon. If the variation be proven a fact, it would be of interest to determine what factors of change in the material, i. e., carbon, temper, chemical composition, etc., were connected with this variation.

Mr. A. A. Cary brought out the fact that coil springs are subject to internal stresses of varying amount and often of considerable importance arising from the methods of manufacture of the spring. In his experience with springs he in a large number of cases found values of G, calculated from the deflections of the springs, ranging from 10,000,000 to 16,000,000; when this value was determined from a piece of the wire directly by twisting the value was practically constant, varying between 12,600,000 and 13,500,000. He also remarked upon the large secondary stresses produced by shearing action, the restraining of the untwisting tendency of the spring, etc., which could not fail to influence the value of G. Stresses of this kind would also largely affect the value of S, the maximum stress; in his work he found, for wire larger than No. 1 gage, S = 100,000 for springs having a coil radius of five times the wire radius, S = 75,000 for springs having such a ratio of 10, S = 50,000 for springs with a ratio of 15. He also stated that in his practice he had never obtained trustworthy and good results with springs having this ratio less than five; the best results he considered are obtained from ratios of seven to nine.

Mr. Geo. L. Fowler remarked that the experiments of Mr. French are in full corroboration of experiments on springs made for the Pennsylvania R. R. some years ago and recorded in the society's transactions by Mr. J. W. Cloud.

Professor Benjamin, in reply to the speakers regretted that Mr. French was not present to answer the various criticisms with the aid of his extensive knowledge of the subject. He personally (Professor Benjamin) attributes the variation in values of G to the secondary stresses mentioned by Mr. Cary, the same remark applying also to the values of S.

WATER POWER DEVELOPMENT AT HANNAWA FALLS.

Mr. Wallace C. Johnson presented to the society a paper on the works constructed at Hannawa Falls, N. Y., to utilize the water power of the Racquette River, which drains a large section of the forest-covered region of the Adirondacks. A description of these works appeared in Engineering News of April 26, 1900. Mr. Johnson's paper was not discussed.

THE PORRO PRISM FIELD GLASS.

The paper, by Past-President W. R. Warner, on "The How and the Why of the Porro Prism Field Glass" was read in abstract by the author. This novelty in optical appliances is a binocular field glass combining an ordinary objective with an astronomical eye-piece. The inversion of the image is neutralized by the inversion produced by a pair of 90° prisms mounted in the tube—one at the side of the ocular slide, the other at the side of the objective. The length of tube required is by this means also shortened to little more than a third that usually required in field glasses. Compactness and lightness in an unparalleled degree are thus obtained, producing also much greater steadiness in using; the use of the astronomical eye-piece secures a field three times as large as that of the ordinary field glass, while the excellent quality of the glass used and the perfection of the mechanical construction give remarkable clearness and accuracy. The discussion brought out some interesting facts. Prof. S. L. Emory stated that it seemed that some of the finer shades of color were lost in the instrument. Mr. Warner, in reply, remarked that this was surprising, as a main feature of the instrument, in fact the feature that rendered the Porro principle practically applicable, was the quality of glass used. This boro-silicate glass possesses remarkably low absorptive power, the selective absorption being also reduced to a very low point. The Porro principle was left unutilized for 50 years only because no glass was available that would leave enough light after the several reflections and passage through the prisms and lenses to give an image of any clearness. The boro-silicate glass first brought out at the Zeiss works enabled the construction of a prism field glass giving even greater clearness and definition than the ordinary field glass, and as far as the speaker knew, there was no reason why the finer shades should be lost with this instrument any more than with the old style. He referred to the work of Mr. J. A. Brashear, member of the society, in the field of optical glass production, and paid high tribute to his successful labors. On several occasions even, German firms, who are recognized as leaders of the world in this class of work, had come to Mr. Brashear for lenses of particular excellence. He also referred Professor Emory to Mr. Brashear himself, who was present. Mr. Brashear then further explained the remarkable qualities of the boro-silicate glass, and suggested that if finer shades were lost in certain cases with the use of the Porro prism glass, any other field glass would show even greater losses. Mr. Brashear in his turn paid tribute to the Warner and Swasey works for the great mechanical perfection of their form of the instrument, which represented such an advance over the European makes as to call out almost at once imitation of the Warner & Swasey type by the German makers.

CLEARANCE AND ECONOMY IN A SMALL STEAM ENGINE.

Prof. Albert Kingsbury, in his paper, detailed some experiments made at the New Hampshire College of Mechanical and Agricultural Arts on the steam consumption of a small steam engine as affected by the clearance. The engine had its crank-end steam passages closed, and this end of the cylinder opened to the atmosphere. The engine was belted to the line shaft of the shop, giving it practically uniform speed at all times. The clearance of the back end of the cylinder could be varied by the insertion of cast-iron rings under the cylinder head from a minimum of about 10% to about 33% of the stroke. The effect on the steam consumption per indicated horse-power was very small, the curve being a straight line with a slight inclination upwards. It will be noted that mechanical losses in the engine could not affect the results obtained with the arrangement used.

Mr. H. E. Longwell, in a contributed discussion, considered that if lower values of clearance than 10% had been used, a sudden rise of the steam consumption would have been noticed. He presented some curves showing such an effect; a Corliss engine with 2½% clearance showed for small loads a much lower economy than a slide valve engine of about 12% clearance. Mr. Suplee presented some indicator diagrams obtained by foreign experimenters showing a downward cusp in the compression line, indicating the beginning of condensation and drop of pressure. This showed too high a compression, he considered, and this might affect the economy. He called attention to the fact that the diagrams of Professor

Kingsbury showed, up to about 20% clearance, traces of such a condensation effect in the form of a reverse curve in the compression line.

Professor Goss mentioned some experiments along the same lines as those of Professor Kingsbury which he had undertaken some years ago. He produced his varying clearance by varying the stroke by means of a wrist pin in the crank disk that could be shifted radially. He had also obtained hook effects similar to those brought out by Mr. Suplee.

The regular program of the meeting was closed with this paper. Secretary Hutton, however, presented to the society Mr. Anthony Victorin, of the Ordnance Department, who had some interesting facts to relate.

ROLLER PRESSURE FOR VERY GREAT LOADS.

In designing the support for certain disappearing guns, it became necessary to support a load of 800,000 lbs. on a rocker resting on a plane bed. To determine the data for proportioning these rockers, experiments were carried out in the following manner. The rocker surface with a radius of 114 ins. was made 12 ins. wide, and rested on a plane block 12 ins. square and 8 to 12 ins. deep. The block was made of different materials in different cases; cast-iron, cast-steel and forged steel blocks were used. The bearing surfaces of both block and rocker were very carefully scraped. Attachments for a micrometer were provided at 2½ ins. from the bearing surface on both rocker and block, giving a total distance between points of 5 ins. The load was increased gradually to the full load of 800,000 lbs.; at 400,000 lbs. the compression by micrometer was about .0025-in., with forged or cast steel and about .0035 with cast iron. At 800,000 lbs. the figures were, for cast steel, .0039-in.; forged steel, .0037-in.; cast iron, .0047-in. With 10 repetitions of load, reducing to 5,000 lbs. in each case, the material was found to be perfectly elastic, no permanent set being observed.

The remarkable fact was noted, however, that on reducing to 5,000 lbs. the micrometer did not come back to zero, but went beyond it, giving a minus reading, and showing an expansion. No explanation could be found for this fact. This minus reading did not diminish even after allowing the apparatus to stand over night.

The experiment was now varied by making the distance between the micrometer points 10 ins.; the average compression of .0040-in. for 5 ins. distance now became .0081-in., showing that the compression extended quite through the material. Tests were then made of the motion of the material laterally at points at varying distance from the bearing face. The results were about alike for both rocker and block. At small distances from the face the material showed motion away from the center, indicating lateral tension; the neutral surface was located at about ⅝-in. distance from the bearing surface. At greater distances than this the material showed motion toward the center, indicating compression.

To determine the bearing area, a sheet of paper was laid between the carefully cleaned bearing faces. The paper had an average thickness of .0012-in. The compressed section afterward showed in the paper like a water mark; this was taken to be the actual bearing area. This bearing strip extended across the face with slightly greater width at the edges than at the middle of the block, a result which might be expected. At 800,000-lb. load this strip had an average width of 1.8 ins. for forged or cast steel, and 2 ins. for cast-iron. At the higher loads a further interesting phenomenon was the occurrence of a greenish strip about ¼-in. wide bordering the bearing strip on both sides for the full width of the block. This was taken to be oil pressed into the paper; it showed that the surfaces of the metal were to some extent porous and held small residual quantities of oil.

It was concluded from the experiments that the load contemplated would be safely carried on a width of 12 ins. by any one of the three materials tested. To determine more closely what degree of safety was involved the block and rocker were cut down to a width of 6 ins., and compression measured as before. The permanent deformation was observed to begin at a load of 550,000 lbs.; at 800,000-lb. load this set amounted to from .0020 to .0025-in. for the different materials used.

The communication of Mr. Victorin was followed with great interest by the members, the phenomenon of expansion which he appeared to have observed being considered worthy of careful examination. It was suggested that the measuring instrument used might have caused error to that extent, the condition being really the simple one of perfect elasticity as observed.

The society, before adjourning, extended its thanks to the committee on the standardization of engines and dynamos and the committee on pipe unions, which had presented to the meeting their final reports on the subjects assigned to them. On motion of Mr. Gus. Henning, a vote of thanks was also extended to Mr. H. H. Camman, who had secured for the society, without compensation, the beautiful services held in dedication of the Robert Fulton memorial at Trinity Church.

In adjourning the meeting, the retiring president, Mr. S. T. Wellman, thanked the society for the honor conferred upon him by his selection for the high office he held during the year just past, and presented to the society its new president, Mr. Edwin Reynolds. The latter, in a few well-chosen words, returned Mr. Wellman's laudatory remarks, and thanked the society for selecting him as its president. The meeting was then declared adjourned until the spring meeting, which will be held in Boston.

RECEPTION AND ROBERT FULTON MEMORIAL.

On Wednesday evening, Dec. 4, the retiring president and the president-elect received the members of the society in the ball room at Sherry's, Fifth Ave. and 44th St. The reception was the occasion of a splendid gathering of members and guests, which continued far into the night. The reception was followed by dancing, which brought even many of the older members of the society out upon the floor. Supper was served until 12, but the last of the guests did not leave until almost 3 o'clock in the morning.

During the past year, a monument to Robert Fulton, inventor of the steamboat, was executed for the society and set in place in the churchyard of Trinity Church at the head of Wall St., on lower Broadway. The monument was formally unveiled on the afternoon of Thursday, Dec. 5, in connection with impressive services in old Trinity. The services were conducted by the Rev. Robert Fulton Crary, of Poughkeepsie, N. Y., a grandson of the inventor. Just before the commencement of the services, the society listened to addresses in Trinity Building, adjoining the church, by Rear-Admiral Melville and Prof. R. H. Thurston. Mr. Melville sketched the life and history of Robert Fulton, bringing out his great service to mankind in his achievements connected with the perfection of the steamboat, while Professor Thurston spoke in praise of Fulton as a man of wonderfully good character. Both addresses and services were graced by the presence of the venerable Chas. H. Haswell, first chief engineer of the Navy, who saw Fulton's first steamboat, the "Clermont," and assisted in the production of his second war ship, the "Fulton II."

THE LARGEST GREENHOUSE IN THE WORLD.

By Arthur C. Johnston,* M. E.

The science of rose growing for commercial purposes has made rapid strides during the last few years, and enterprising florists, having exhausted every other means of obtaining a maximum production from their plants, have turned their attention to securing the construction of greenhouses best adapted to their needs. The size of such greenhouses has been increasing to such an extent, that their design must eventually become a matter of interest to engineers. As an interesting example of what has been done lately in this direction, the accompanying sketches show the construction of what is at present the largest greenhouse in the world. It was built at Edgely, Pa., in the summer of 1901, and is 307 ft. long, 54 ft. wide, and has a capacity of 11,000 plants.

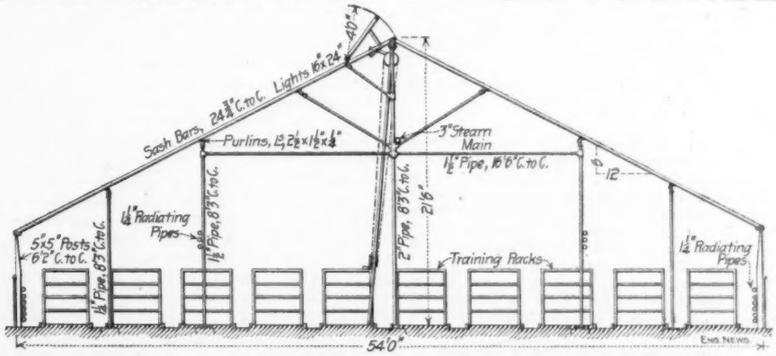


FIG. 1. CROSS-SECTION OF GREENHOUSE FOR ROSE CULTURE AT EDGLEY, PA.

The requirements of a good greenhouse are as follows: It must be as large as possible, without an excessive ratio of length to width. The glass must be kept as far as possible from the plants, in order to avoid the excessive heat in summer and the cold in winter. There must be cubical capacity sufficient to insure an abundant supply of pure air. The most important requirement of all is that the form of building, and size of members, must be such as to cast a minimum of shadow within the house. With all other requirements, it must be inexpensive.

By referring to Fig. 1, it will be seen that the Edgely house has a peak roof with a pitch of 6 ins. in 12, and that the width of the building is 54 ft. This width was determined by the maximum length of sash-bar obtainable, namely, 31 and 32 ft. Accordingly, the 32-ft. bars are used on the ventilator side, and the 31-ft. bars on the other side. The sash-bars are of novel form, and their cross-section, and the method of securing the lights to them, are shown in Fig. 2. It will be observed that the glass is embedded in putty on the under side only, and that any water that should possibly leak between the bar and the glass will be caught in the drip trough "a," and be carried down to the eaves. The lights are 16 × 24 ins., and the sash-bars are spaced 24¾ ins., c. to c. The matter of giving the glass a span of 24 ins. is somewhat of an innovation. The lights are held in place by two patent glazing points per light, driven in such a way as to prevent the glass from moving, as is shown in Fig. 2. It will be noticed also, that the lights are overlapped by but 1-16-in. It is a peculiar fact that the smaller the lap, the less liability there is of leakage between lights. This is, no doubt, due to the elimination of capillary action, on account of the reduced lap.

The purlins are 2½ × 1½ × ¼-in. angles, and have a clear span of 8 ft. They are secured to the posts by means of a small casting, which is bolted to the purlins and to a screwed cap on the top of the columns. All the columns are composed of pipes. The center row is of 2-in. pipe, the intermediate rows of 1½-in., and the outside rows of 1¼-in. pipe. The purlins next to the peak, and the foot of the ventilators are supported by inclined struts from the center row of columns. The ventilators are 8 ft. 3 ins. long, and they are spaced 10 ft. 4 ins. c. to c., so that there is an opening 4 ft. wide, and practically continuous from one end of the building to the other. The method of operating the ventilators is shown in Fig. 1. There are three hand-wheels for the entire building, or ten ventilators on each machine. There is a small lip on the top sash of the ventilators which, when closed, overlaps the plate at the peak of the roof. This allows the drip to fall off, and thus prevent the sash from freezing shut in winter.

For heating the house, a 3-in. steam line is carried down the middle row of columns, and this is tapped at the center of its length and at one end of the building, into the radiating pipes. There are 18 lines of these, 6 of which are suspended by wires from the intermediate rows of columns, and 12 are carried along the outside rows of posts. The

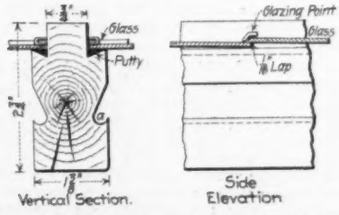


Fig. 2. Details of Glazing of Edgley Greenhouse.

latter are supported on roller hangers composed of a short piece of ¼-in. pipe through which a wire nail is driven into the post. Each radiating pipe is controlled by a separate valve, except the lower lines along each side of the building, of which the bottom four are connected to one valve for each side. There is a total of 5,500 lineal feet of 1¼-in. pipe, and 310 ft. of 3-in. pipe, which gives a total of 2,706 sq. ft. of radiating surface. This heat-

*Bristol, Pa.

ing surface is expected to be capable of maintaining a temperature of 80° F. in the coldest weather. All the pipes are provided with brass expansion joints.

At first glance this building seems to be ridiculously light for a permanent structure, but it must be remembered that the roof is never called upon to withstand any snow load on account of the heat inside, and as the dead weight is so small, the roof is therefore capable of resisting quite a heavy wind. It is in greatest danger, of course, from internal wind pressure, a condition that might easily occur if doors were left open on the windward side. The greenhouse as it stands shows a remarkable stability under winds of considerable force. There is no doubt that this example of greenhouse construction is but the forerunner of much larger structures of this class.

BOOK REVIEWS.

HOUSE AND ROOF FRAMING.—By Owen B. Maginnis, author of "Bricklaying," "How to Join Moldings, Etc.," etc. A practical treatise on the latest and best methods of laying out, framing and raising timber houses on the balloon principle; together with a complete and easily understood system of roof framing. Published by Owen B. Maginnis, 310 W. 128th St., New York. Cloth, 7¼ × 10¼ ins.; pp. 96; illustrated. $1.

This is a sixth edition of this book, revised to conform with the latest practice. With the assistance of illustrative drawings the author describes the various steps in framing and erecting timber houses after the so-called balloon-frame method, including in this the erection of dwelling houses, factories, timber grain elevators, etc. The second part relates to the framing of the timbers in a brick house, fireproofing wooden floors, partitions and doors, and composite wood and iron construction. The last part deals with roof framing of various types. The text is the work of a carpenter rather than that of a professional maker of technical books; and as a consequence it contains many practical suggestions and methods that the less experienced man would probably have omitted.

LESSONS IN PRACTICAL ELECTRICITY.—By C. Walton Swoope. Cloth, 5 × 7½ ins.; pp. 462; 385 illustrations, 2 plates, 32 tables. D. Van Nostrand Co., New York, N. Y. $2.

The author of this work was, up to the time of his death a few weeks ago, instructor of applied electricity at the Spring Garden Institute, Philadelphia. To aid in teaching his large classes, a private edition of the present work was issued some five years ago. It is now published for wider distribution, for use as an elementary text-book on electricity and for self-instruction. It is admirably adapted to these purposes. Beginning with a clear and simple exposition of the phenomena of magnetism presented in the form of experiments, all of which are intended to be actually carried out by the student, it passes on to the consideration of the electric current and its connection with magnetic manifestations, leading up to the study of commercial forms of electrical machinery as applied to industrial purposes. At all points the explanation is made as clear and exact as can well be done, and all conclusions are definitely stated in rules set out from the explanatory part. It is especially gratifying to note the absence of any reference to phenomena of static electricity, a subject that in so many cases greatly retards full appreciation of electrical facts. No attempt, also, is made to treat alternating currents in any way, and every page has for its clear purpose the inculcating of a thorough elementary comprehension of the subject of direct current electrical practice. The book seems better adapted to self-instruction as well as to class instruction in the field it claims to cover than any other work we have seen. All formulas and rules are collected in the back of the book, followed by a series of tables required in the solution of the problems given in the book, a feature that will make the book valuable to many who have progressed beyond its range in their study of the subject.

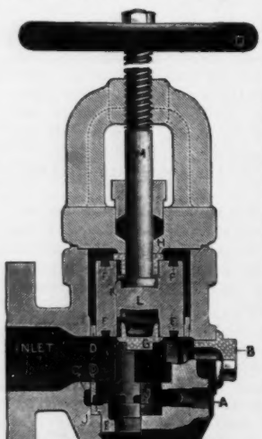
THE ANTHRACITE COAL INDUSTRY: A Study of the Economic Conditions and Relations of the Co-operative Forces in the Development of the Anthracite Coal Industry of Pennsylvania.—By Peter Roberts, Ph. D., with an introduction by W. G. Sumner, LL. D., Professor of Political and Social Science in Yale University. New York: The Macmillan Co. Cloth: 6 × 8¾ ins.; pp. 267; illustrated. $3.50.

In this work the author deals purely with the economic features of the anthracite coal industry, though he first describes the deposits, their development and the methods of working the coal beds. The chief points discussed are: Capitalization, transportation, mine management and inspection, employes and wages, incidental profits of operators, accidents, strikes, unionism and reclamation of wastes. This Pennsylvania coal region covers about 1,700 square miles of territory, and furnishes employment to 140,000 people; and in this field the author has had exceptional opportunities for studying the topics here handled. As a result we have under each of the above broad heads a very large mass of detail that is of great importance and value to those engaged in this industry, both from an historical point of view and that of the operator of to-day. He illustrates by actual figures intelligently arranged, and from these figures and his own observations he deduces his conclusions. His last chapter sums up his ideas upon the conditions of peace and prosperity to both capital and to labor. The author broadly approves of the capitalistic system, or trusts as the latest product of civilization—provided that this vast capital is honestly and intelligently handled and used in introducing better system and discipline into the coal industry. He generally approves of organized labor, as labor needs the advantages and benefits derived from organization. But he also believes that there should be a better and more intelligent understanding between capital and labor; disputes should be settled by boards of conciliation, and labor should be made to feel that it is something more than a commodity and is actually a partner in the work of production. He tells the laborer that, under modern economic conditions, he cannot expect full pay for half-work, nor can he look for a paradise where all the necessaries of life are provided without work. In dealing with the foreign labor element—the most unreasoning and dangerous in the coal regions—the author sees no other remedy than patience and a better education for the young, physical, mental and moral. And, finally, in regard to the great inequality in the distribution of wealth, so often complained of, he points out that the true difference between the miner and the capitalist is one of quantity and not quality. The principle regulating the profit is the same in both cases, but one deals with hundreds where the other handles millions.

A NEW BOILER BLOW-OFF VALVE.

The design of a boiler blow-off valve or cock which shall always be tight when closed and never give trouble in opening or closing, is one which has balked many engineers. From its position the blow-off valve is exposed to scale, sediment, grit and everything which is naturally expected to cause valves and cocks to leak and stick. But a leaky blow-off valve is not only wasteful but dangerous, for the loss of water, while the boiler is shut down and the fires are banked may proceed to a serious extent. Still more serious is the predicament of the engineer who opens the blow-off cock, and when he attempts to shut it finds that a piece of scale has lodged on the seat; or if it is a cock it may stick, as cocks are prone to do, and the handle may break off when it is half-open or closed. These things make many engineers loth to use the blow-off except as necessity compels, and they allow boilers to accumulate scale by blowing-off at too long intervals.

A blow-off valve designed to obviate these defects has been designed by the Lunkenheimer Co., and is shown in vertical section in the accompanying cut. The main feature of the valve is the use of an auxiliary steam supply which blows the bearing surface clean as the main valve approaches its seat. The construction and operation of the valve are described as follows by the manufacturers:



The steam inlet A connects with an annular passage C. The iron body of the valve has a brass casing D with a circular slot J cut into its side just below the level of the seat E. This casing D is held in place in the valve body by the seat ring E screwing over it, both of which are removable at any time for repairs or replacement. The opening A is connected to the steam space of the boiler and a suitable valve interposed. The object of this steam inlet A is to admit steam to C and J, and discharging from the latter blows across the seat, which will clean off any scale or sediment that may have accumulated on it, so that the disk and seat bearing, when in contact, will be perfectly clean.

To close the valve, the disk is screwed down in the usual manner. As it approaches the level of the inlet the edge of the disk passing the lower edge of the casing D cuts off a great deal of the flow of water, sediment, etc. At this time the valve in the steam pipe leading to inlet A should be opened and the steam admitted to the annular space C, from whence it passes through slot J and blows off the entire surface of the seat E. In the meantime the disk is being screwed home to the seat, which cuts off the flow of steam from inlet A as well as the blow-off from the boiler.

It will be seen further that the disk is reversible, so that when one bearing face is worn the other can be used. The seating-faces on the disk are Babbitt metal filled into dove-tailed slots and faced off; and when these seats are cut and worn, the old metal can be melted out, the grooves refilled and faced anew. The plug B permits a rod to be introduced to clean out the blow-off pipe back of the valve when it becomes choked with mud and scale.

A BONUS SYSTEM OF REWARDING LABOR.

At the annual meeting last week of the American Society of Mechanical Engineers, a full report of which is given elsewhere in this issue, a paper was read by Mr. H. L. Gantt, of the Bethlehem Steel Co., describing a system recently put into practice there for securing more efficient and cheaper work, and at the same time increasing the output of the shop. The methods of arranging work, and the results obtained through the system, as described in the paper and in additional remarks contributed by Mr. Fred. W. Taylor and others, are remarkable, and aroused great interest among the members. As they will probably prove of equal interest to wider engineering circles, we give below a comprehensive abstract of the paper and the discussion upon it:

The system described in this paper has recently been introduced by the writer into the large machine shop of the Bethlehem Steel Company, and has met with unqualified success. It is an attempt at harmonizing the interests of the employer and employee, and, while it affords substantial justice to the employee, requires that he shall always conform to the best interests of his employer. That it accomplishes such a result, at least in a measure, is shown by the fact that it has caused a complete change in the whole atmosphere of a shop, notwithstanding the fact that it has been in operation for a few months only.

DESCRIPTION OF SYSTEM.

A card is made out, showing in detail the best method (so far as our present knowledge goes on the subject) of performing each of the elementary operations on any piece of work, specifying the tools to be used, and setting the time needed for each of these operations as determined by experiments. The sum of these times is the total time needed to complete the piece of work. If the man follows his instructions, and accomplishes all the work laid out for him, as constituting his proper task for the day, he is paid a definite bonus in addition to the day rate which he always gets. If, however, at the end of the day, he has failed to accomplish all of the work laid out, he does not get his bonus, but simply his day rate. If he finds any operation which cannot be done in the time set, he must at once report it to his foreman. If on careful investigation by the man making out the card the workman's statement is found to be correct—that a portion of the task can not be done in the time stated on the card—a new instruction card is made out, explaining the proper method of working, and allowing the proper time. It is of the greatest possible importance for the moral effect upon the men that errors in making out instruction cards should be as few as possible. A man must be allowed time only for what is stated on his card, and while a reasonable time must be allowed for each operation, he should fail to receive his bonus if time is lost from any cause whatever. (The foremen also receive, in addition to their day wages, compensation proportional to the number of their men who earn a bonus, and an extra compensation if all of their men earn their bonuses.)

It will be seen at once that this method is really a system of education, with prizes for those who learn, and the results already obtained bear out this idea of education most fully, for under it men have learned more in a few months than they ever did before in years.

A careful consideration of the system will show that, while it is not a system of piece work, it has many of the advantages of differential piece work, by which I mean that the compensation is *quite large for the maximum amount of work obtainable, and quite small for anything less than this amount.* For instance, if a man does all that is asked of him, which must always be possible, he gets a large extra reward; but he gets no reward, except his ordinary day rate, if he falls short of this amount. The extra bonus which the bosses earn when all of their men perform the maximum amount of work is a strong inducement to make them teach their inferior men.

DEVELOPMENT OF THE SYSTEM.

This system is, so far as the writer is aware, a new one, but is based on the principles of Mr. Fred. W. Taylor's system of elementary rate fixing,* and is as far as possible removed from the old fashioned method of fixing piece rates from records of the total time it has taken to do a job. It possesses an advantage over direct piece

*Engineering News, July 4, 1895.

work in that it is more flexible and can be introduced with greater ease and under conditions where piece work proper would be impossible. While the men who are on day work usually realize that they are not doing all they can do, when they are told that it is possible to do three or four times as much as they are doing they simply do not believe it, and it is very difficult to make them accept as just a piece rate founded on this basis; but a reward in addition to their day rate constantly held before them will finally be striven for by some one, and when one has obtained it others will try for it.

In order to get the information necessary to fix proper piece rates, or even to make out good instruction cards, a very large amount of detail work is necessary. When we realize, however, that any operation, no matter how complicated, can be resolved into a series of simple operations, we have grasped the key to the solution of many problems. The logical method, therefore, of studying a complicated operation is undoubtedly to study the simple operations of which it is composed, a thorough knowledge of which will always throw a great deal of light on the complex operation.

Such study divides itself into three parts, as follows: (1) An analysis of the operation into its elements; (2) A study of these elements separately; (3) A synthesis, or putting together the results of our study.

This is recognized at once as simply the ordinary scientific method of procedure when it is desired to make any kind of an investigation. It is well known to all that until this method was adopted science made practically no progress, and the writer believes that if it is desired to obtain the correct solution of any problem we must follow the well-beaten paths of scientific investigation, which alone have led to reliable results. The ordinary man, if left to himself, seldom performs any operation in the manner most economical, either of time or labor; it has been conclusively proven that even on ordinary day work a very decided advantage can be gained by giving the men instructions as to how to perform the work they are set to do.

Mr. Fred. W. Taylor, who was the pioneer in this work of elementary rate fixing which involves complete detailed instructions, began to work on these lines in 1880, and soon became convinced that they were correct. He has fixed a large number of rates, all of which are lower than those usually paid, but as he takes care to furnish the best implements for doing the work, and insists that the work shall be done as he instructs, the good men always make better wages than they can where they are allowed to do the work with the implements and in the manner they see fit. His piece rates, founded on careful investigation, and with an earnest attempt to do justice both to the employer and the employee, have produced not only a much greater output than any other method in the works where they have been introduced, but a much better feeling among the men toward their employers.

The scientific method of investigation of the elements into which every operation may be divided is then evidently a satisfactory basis for fixing piece rates, and it should always be employed whenever it is desired that the rates shall be permanent. To analyze every job and to make out instructions as to how to perform each of the elementary operations requires a great deal of knowledge, much of which is very difficult to acquire; but the results obtained by this method of working are so great that the expenditure to acquire the knowledge is comparatively insignificant. Such instruction cards will seldom represent the very best method of performing the work, but will usually represent a method far superior to that which the ordinary workman would employ, and if we can get the men to do the work as directed on these cards, we can very largely increase the efficiency of their work. This is a most obvious way of increasing our output when we have not sufficient information to make out permanent piece rates. To base a piece rate on such an instruction card, however, would be simply inviting trouble, as but few men could see that it was just to change a piece rate when we changed the method of doing the work. If, on the other hand, we allow the men their day rate and offer them a bonus or premium for doing the work in accordance with our instruction cards, they see at once that they will have nothing to lose by conforming to our wishes, and all to gain, with the result that they will in a short time make an effort to do the work in the manner and time set. We have found that there is practically no objection on the part of the men to a change of time on these cards, so long as the new time corresponds to a new set of instructions which will enable them to perform the work in the time set.

APPLICATION OF INSTRUCTION CARDS TO A MACHINE SHOP.

In order to make proper instruction cards for a machine shop doing a variety of work it is necessary to know the laws of the cutting of metals, as well as the time for handling work in this particular shop. The laws referred to are very complicated, but here again, Mr. Taylor has made such a start as to render it possible to determine the best method and time for rough-machining steel. The results of his experiments on lathes were reduced to a slide rule by the writer for convenient use. This slide rule has been improved by Mr. Carl G. Barth, who has also extended it to planers, drill presses and slotters, and who made out slide rules for a number of machines in the large machine shop of the Bethlehem Steel Company. By means of these slide rules we can determine promptly the most economical feed and speed with which to perform any operation on a piece of steel when the physical qualities of the steel are given.

ROUTING.—The drawing first goes to an expert mechanic, who has charge of what is known as the routing of the piece through the shop. He decides the order in which the various operations of turning, planing, slotting, drilling, etc., are to be done. In a shop doing a variety of work, too much stress cannot be laid on the routing, for, besides the advantage of knowing in the office the progress of the work, the saving made by performing the various operations in the best order is very great. This subject of routing is large enough to take up a paper by itself, so it can only be mentioned here. If the first operation to be performed is that of turning, the forging is assigned to the lathe best fitted for handling this particular job.

ANALYSIS.—The work to be done on the machine is then analyzed by a first-class machinst, who has been instructed in the use of the slide rule, and who makes out an instruction card on which the operations to be performed on this lathe are placed in the proper order, with proper instructions, the calculated time being given for performing each operation. The kind of tool to be used, the feed, and speed are specified for every machine operation. For every other operation, such as putting in and taking out work, laying out, changing feed gears, etc., instructions are given, and the time that each should take is placed directly opposite the description, in a column designed for that purpose.

INSTRUCTION CARDS.—I show herewith a sample card for rough-turning a locomotive piston rod. This card represents instructions given to William Jones, whose boss is Thomas Smith, to do work on Forging No. 14,653C4, Manufacturing Order No. 17,344, in Lathe No 145, according to Standing Order No. 376. The hardness of the metal is represented by class 12. He must use tools made of "M E" steel, of the shape designated in the column calling for shape of tool. The approximate depth of cut in turning is 3-16-in. "J" represents a combination of feed gears, and "2-BF" a cone speed which he must use. Opposite each operation are seen complete instructions giving the kind of tool, cut, feed, and speed that must be used in order to accomplish the work in the time set. The total time for turning and facing this forging is shown to be 42 minutes. At the bottom of this card is given, first its number, then the drawing number of the assembling sheet, if we have such a sheet; then the detail drawing for this particular piece, and next the date and signature of the man who made out the card. The note at the bottom, namely: "When machine cannot be run as ordered, speed boss must at once report to the man who signed this slip," is put on in red ink and should be observed to the letter.

Sample Instruction Card as Used in Machine Shop No. 2, Bethlehem Steel Co.

Class of Work, Lathe.	Standing Order, 376				Order Number, 17,344		
Machine No. 145	Tool, M E	Class of Metal, 12			Forging No. 14,653c 4		
Man's Name—William Jones.		Speed Boss—Thos. Smith.					
Description of operation.	Shape of tool.	Cut.	Feed.	Speed.	Time work should take.	Time work did take.	Rate.
Chuck	....	..	..	....	2.5	..	..
Face end	P V M	..	..	2 B F	4.0	..	..
Turn half way	P R L	5/16	J	"	12.0	..	..
End for end..	....	..	..	....	5.0	..	..
Half way	P R L	5/16	J	2 B F	12.0	..	..
Face end	P V M	..	..	"	4.0	..	..
Remove from machine ..	.. ....	..	..	....	2.5	..	..
Total	....	..	..	....	42.0	..	..

Instruction Card No. 4327.	Sheet	Drawing No.	B.S.Co. 26,627¼c.	Drawing No.
Month 6	Day 1	Year 1901	Signed Buckley.	

When machine cannot be run as ordered, Speed Boss must at once report to man who signed this slip.

THE BONUS FEATURE INTRODUCED INTO THE SYSTEM.

This system of instruction cards was introduced by the writer into Machine Shop No. 2, of the Bethlehem Steel Company, in June, 1899, with markedly beneficial results. An important difficulty remained, however. There was comparatively little difficulty in causing the men to perform the automatic operations according to the instructions given, i. e., they would run their machines at the feed and speed called for, but the great difficulty was that it seemed impossible to prevent them from losing time between operations. No matter how efficiently the machines were run through their actual working time, the men found good excuses for taking more than the prescribed time on every job, and for wasting enough time to hold down the output of the shop very materially.

To overcome this difficulty it was proposed by the writer that every man who succeeded in doing all the work called for by his instruction cards for a complete turn should receive a bonus, or premium. When this payment of a bonus went into effect, the amount of time wasted diminished very rapidly, and soon a majority of the men on the machines were earning their bonuses regularly. In order to be sure that they got all the assistance possible from the foreman, he, too, received a definite premium for each machine under his charge that made its bonus. In order that the poorer men might receive sufficient instruction from the foreman, it was made to his interest to give special attention; he was given an additional 50 per cent. if all the machines under his charge earned their bonus, thus making it to his interest to give special attention to the men most likely to fall behind.

Inasmuch as no bonus whatever is paid unless the men actually perform the work called for on their instruction cards in the time set, it is to the interests of the men to prevent accidents to the machines, and to avoid unnecessary delays, whether such delays are their own fault or the fault of other people. Among the results we have obtained are: (1) A very large increase in output, averaging from 200 to 300 per cent.; (2) A falling off in accidents and breakdowns; (3) A quickening of the intelligence of the men.

For instance, men who could formerly do nothing for themselves, but were obliged to ask the foreman all kinds of questions, now find that they can do the work by asking fewer questions, for if they spend a large proportion of their time hunting the foreman they lose their bonus. One man, for instance, who in three years had never learned to change the feed gears of his machine properly without the assistance of his foreman, lost his bonus three days in succession because they had not been properly set. He at once learned to set them, and has had no difficulty from this cause since.

BONUS SYSTEM vs. PIECE WORK.

If we have a thorough knowledge of all the conditions, and are able to introduce piece work, it is undoubtedly to be preferred; but we must remember that there is nothing so demoralizing as cutting piece rates. The difficulty of introducing a bonus system is far less than that of introducing direct piece work, for if workmen, having secured to them their day wages, are given such instruction cards, and a considerable reward is held out to them for doing the work in the manner and time called for in the instruction cards, they will gradually overcome their prejudice against following instructions, and finally attempt to perform some of the operations in the time set. Having performed a few of these operations, and finding out that the card represents a fair and reasonable set of instructions, they will, in a short while, conclude that they might as well have the extra pay, and gradually learn to follow the whole card. This has been the experience of the writer, and he was surprised to find out how quickly the men overcame their prejudice. Before the introduction of the bonus men seldom complained to a foreman that they were being interfered with, but simply sat down and waited, and would sometimes wait for a crane by the hour. Now all are up in arms against anybody who does not serve them almost instantly.

To make out instruction cards requires, as already stated, an amount of knowledge and experience that is seldom the possession of any one man. To obtain this information requires a long series of detail observations and investigations with corresponding records, and even after having obtained a great deal of such information, most of our instruction cards will still fall far short of perfection. If subsequent to having made out a card for a certain job we have obtained more information on that job, and find an easier and quicker method of doing the work, our instruction cards may be made to conform to the new and better method, but only such items on the instruction card should be changed as are affected by this new and better method; no wholesale change in a card is allowable under any conditions. It must be possible always to perform the individual elementary operation in the time set, and when a man cannot do this, and the foreman cannot show him, the matter should at once be referred to the man making out the instruction cards. This throws the responsibility for the success of the system on the man making out the instruction cards, who should not only be a good mechanic, but a man of the highest order of intelligence and integrity, for he practically fixes the pay of the men and is in a large degree responsible for the output of the shop. This is true, whether the instruction cards are made out for a bonus system or for piece work, and unless a proper man is selected to have charge of this work, the whole system, whether that of paying a bonus or piece work, will immediately fall into disrepute.

EFFECT OF BONUS SYSTEM ON SHOP OUTPUT.

During the year from March 1, 1900, to March 1, 1901, the machine shop was run day and night as hard as the machines could be pushed by day work alone, and still the increasing output of the forge was piling up work ahead of it. It was at this juncture that the bonus system was put in operation. To realize what happened in the few months after the introduction of the bonus, it is, perhaps best to compare the shipments during those months with the average monthly shipments for the preceding year. I do not feel at liberty to give the actual shipments, but if we represent by unity the average monthly output of the shop during the year from March 1, 1900, to March 1, 1901, the following figures will represent the output for the five months succeeding the introduction of the bonus system:

Average shipments per month for year from March 1, 1900, to March 1, 1901.	.....	1.00
Shipped in March, 1901	.....	1.25
" " April, "	.....	1.53
" " May, "	.....	1.86
" " June, "	.....	1.98
" " July, "	.....	2.17

The bulk of the above shipments consisted of rough-machined forgings, and before the end of July the machine shop had caught up to the forge so closely that there was not enough work to keep all the machines running day and night and a large number were shut down on the night turn.

A NEEDED ADDITION.

Although the results as above pointed out are very far in excess of what was anticipated, the writer does not feel that we have yet taken advantage of all our opportunities. As before stated, the system is one of education, with prizes for those who learn, but the prizes have so far been awarded for learning and doing only what our experts already knew. The next step is to make it to the interest of the men to learn more than their cards can teach them. So far nothing has been done in this line for the reason that no entirely satisfactory method has suggested itself.

The writer believes in paying a liberal compensation for improved methods of work, and in offering special inducements to a workman to make out instruction cards, by which others are enabled to carry out his methods. The compensation should be sufficiently liberal not only to induce him to part with what information he may have, but to use his ingenuity to devise better methods.

If this can be properly carried out, the most difficult problem of the system—that of training men to make out instruction cards—will have been solved, and the system will not only become self-perpetuating, but will automatically pick out the men best suited to carry it forward.

DISCUSSION.

After some commendatory remarks by various speakers, Mr. F. A. Halsey brought up the question of the extent to which a system as described was applicable to the general machine shop. He pointed out that the work handled at Bethlehem was all large work, for which the careful analysis and administration described would be economically possible; that most of the work done there was roughing, practically no finishing being done; that the work was all on steel, and on material the composition and qualities of which were accurately known, it being all made on the ground. He questioned whether the system was applicable at all to a machine shop dealing with a variety of work, yet not producing large numbers of duplicate parts; the great amount of administrative and skilled work would introduce an element of cost that would require large resulting economies to make it pay for itself. With a variety of work as described such economies could not be attained.

Mr. Buckley, who at the time the system was introduced was foreman in the machine shop referred to by Mr. Gantt, and who now is the head of the instruction and routing department in that shop, contributed a written discussion, in which he illustrated by a number of examples how a stupid and ignorant man may be brought to do very efficient work. As illustrating that a workman's guess was rarely as good as a skilled man's analysis, he mentioned cases where workmen in good faith had asked to be permitted a trial of their own way of doing a job, and the request had been acceded to. In every case of this sort the man was unable to make the time that was reached by following the method of the instruction card.

The discussion of the paper was interrupted at this point, as the society was compelled to adjourn to get downtown in time for the Fulton Memorial dedication services. The subject was taken up again at the opening of the session on Thursday evening, with remarks from Mr. Fred. W. Taylor elaborating on the history of the system at Bethlehem and the application generally of a scientific course of analysis of industrial operations to economize cost.

Mr. Taylor stated that the paper of Mr. Gautt treated of two distinct matters which ought properly to be taken up separately. These are (1) the differential rate system, and (2) elementary rate fixing. The first mentioned was the development from the former, and its origination is due to Mr. Gantt. The second was begun, as Mr. Gantt stated in his paper, twenty years ago by Mr. Taylor and has since been applied by him in a great number of cases.

As an extreme yet representative example of the analysis connected with the elementary rate fixing, Mr. Taylor instanced dirt shoveling. For some time past at Bethlehem several men have been carefully studying this subject with the help of stop watches. Shoveling was divided into three independent operations: pushing the shovel into the material, drawing it out again, throwing its load. The first mentioned operation will vary much with the kind of the material, the second varies but little, the third depends mainly on the load on the shovel. It was soon found that a strong and heavy shoveler did his best work with a load of 22 lbs.; for the ordinary laborer, however, this figure was only 12 to 14 lbs. Shovels were thereafter handed out to the men that would give a load of 22 lbs. with the material to be handled. After a time piece rates were determined and placed so low that at the ordinary rate of work of a shoveling gang the laborer could not earn a day's wages, but at the rate that it was expected to attain they could earn more than they had been making. The results of this system were remarkable. At present 85 men do the work formerly done by about 400 men, and these men earn $1.85 where thew formerly could earn only $1.15. The labor cost per ton, for instance, of loading certain material into cars is now 4 cts. where it formerly was 9 cts. Of course, as soon as the method was introduced men began dropping out; on the average only one in fifteen could stand the pace. But soon men began coming in from all over to do the work, men that were heavy and strong and were glad to have a chance to make 70 cts. more per day than they could earn elsewhere. The men are satisfied and happy at this rate; there are no drinkers, for drinkers could not stand the pace; all of them have money in the bank. Here a careful balance must be held not to pay them too much, they would otherwise become spendthrifts and soon be unfit for work.

In applying any such system of elementary labor-control to a shop Mr. Taylor begins with the foreman; as there are not one-tenth enough good foremen to be had, he often used the expedient of splitting up the work among a number of men. In the shop where he has carried this to the farthest point yet reached, he has a speed boss, who controls tools, setting of machines, and speeds in general; a gang boss, who portions out the work and keeps the machine supplied with work and the machine fittings required to do that work, at least a day ahead of time; an inspector, who controls quality of work; a time boss, who has charge of times, costs, etc.; a repair boss, who has the care of the machines and tools; and lastly, the instruction department, which lays out the methods of work and draws up instruction cards. The shop also has a disciplinarian, who settles all disputes and quarrels between men and foremen. The speaker enlarged on the working of this scheme at some length; it brings about co-operation between the men and between the bosses, etc.

The speaker still emphasized, however, that the instruction and rate fixing department was the most important element. This concentration of laying-out and planning in a single department, instead of letting each workman do it for himself, he considered essential to efficiency, aside from the fact that it is necessary for rate control. He said it bore the same relation to the administrative side of the shop as did the drafting room to the mechanical side, and predicted that in twenty years every good shop would have a department of that sort and consider it as important as it now considers its drafting room.

Following Mr. Taylor, Mr. M. P. Higgins said that the paper of Mr. Gantt was so advanced as to be in danger of rejection from that very cause; but, he continued, it is so thoroughly scientific and practical in its development and its results that it might truly be called epoch-making.

Mr. J. M. Dodge stated that his concern had some years ago "Taylorized" their establishment. He had nothing but praise for the methods and results. They had made an addition: they charted their establishment, and included in this diagram not only the mechanical operations, but also the business methods. Nowadays, when any change is to be made, the chart is used as a guide.

THE BURSTING OF SMALL CAST-IRON FLYWHEELS.*

By Charles H. Benjamin,† M. Am. Soc. M. E.

In November, 1898, the writer read a paper‡ before this society on the subject of small flywheels, detailing the results of some experiments made in the laboratories of the Case School.

The discussion of the former paper and suggestions received from various engineers since its publication, have led to further experiments on wheels of peculiar design These experiments were all conducted under the immediate direction of the writer, and he was present at most of the destructive tests.

The wheels numbered 1 to 9, inclusive, were tested during the winter of 1899-1900 by senior students Messrs. Clyne and Mühlhäuser; while those numbered 10 to 16 were tested during the present year by Messrs. Austin, Mills and Stanford, instructors in the school. The wheels were all of cast iron, 24 ins. in diameter, with proportions copied from existing wheels. The general method of testing was similar to that used in the former experiments, but new apparatus was designed and built for greater convenience and safety.

Former tests had shown the insecurity of a wooden shield or cage for the bursting wheels. Fig. 1 shows the form of shield used in the later experiments. A cast-steel ring 36 ins. in diameter inside, and having a rim section 4 × 6 ins. was enclosed and supported by a wooden framework, the front and back being of oak plank, 3 ins. thick. To absorb the energy of the flying fragments a sectional lining of Norway pine was used, as this could be easily repaired and renewed after each test. During the 16 experiments recorded but one wheel managed to escape from the shield, and this was due to the breaking of the bolts confining the side planking.

The wheels were keyed to the overhanging end of a steel shaft, $1^{7}/_{16}$ ins. in diameter, running in a long bronze bushing and coupled loosely to a Dow steam turbine. The speed was measured by means of a [illegible] belted tachometer, the speed being reduced [illegible] 1 to 10. Belts made of two thicknesses [illegible] tric tape stitched together were found to [illegible] at the speeds used, being free from slip. All of the wheels tested were balanced carefully by [illegible] wire around the arms, close to the rim.

Wheels Nos. 1 and 2 were cast with solid [illegible] modeled closely from a flywheel 10 ft. in [illegible] Allis engine. These were tested to furnish [illegible] comparison for the other wheels. Fig. 2 [illegible] and proportions of this class, and the accompanying table gives the principal dimensions. These two [illegible] at 3,700 and 3,850 revolutions per minute, respectively or at an average rim speed of 395 ft. per second. This corresponds to a centrifugal tension of about [illegible] per sq. in. The fracture showed clean iron of uniform quality.

The four wheels numbered from 3 to 6 [illegible] had two flanged joints in the rim, as shown in Fig. [illegible] These joints were of the same general proportions as those described in the previous paper. At the suggestion of Mr. Jas. B. Stanwood, of this society, they were located at points one-fourth of the distance from one arm to the next, those being approximately the points of least bending moment. As shown in the table, these wheels burst at an average rim speed of 194 ft. per second. This corresponds to a centrifugal tension of about [illegible] lbs. per square inch.

These wheels were, then, only one-quarter as strong as similar wheels with solid rims, and burst at one-half the speed. Comparing these with wheels of similar construction tested in 1898, we find that moving the joint from the center to the quarter point has made no appreciable difference in the strength. This is, doubtless, due to the fact that the heavy mass of the flanges and bolts locates the bending moment at or near them.

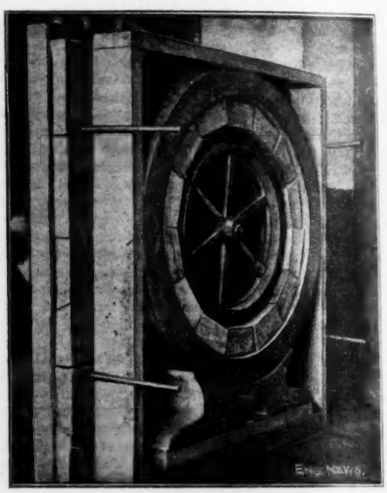


Fig. 1. Casing Used in Driving Cast-Iron Flywheels at Bursting Speed.
(Front of Casing Removed.)

Fig. 3 shows the general manner of fracture of these wheels; strange to say, the joints usually remained intact—the bolts being slightly stretched—and the rim broke close to the joints, as shown in the cut. The combined tensile strength of the bolts in the flange joints was about 20,000 lbs., or less than one-third the strength of the solid rim, which is about the maximum ratio possible with this style of joint.

Wheel No. 7 was a complete working model of a flywheel for a blowing engine, and was copied from drawings furnished by a well-known firm of engine builders. The construction is clearly shown in Fig. 4, and the dimensions are given in the table. The joints in the rim were carefully fitted and the links shrunk in. This wheel burst at 2,450 revolutions per minute, and a rim speed of 256 ft. per second, which indicates a centrifugal tension of about 6,600 lbs. per square inch, and shows that this wheel is nearly twice as strong as those just described. As may be seen by reference to Fig. 5, the wheel broke in every instance through the smallest section of the rim near the joint, the links remaining intact. It is interesting to note that every bolt in the hub was shaved off clean as by a knife, each arm pulling out in this way.

Soon after the publication of the previous paper, the writer had some correspondence with Prof. Archibald Sharp, of London, Eng., which resulted in the latter's sending to this country two model wheels to be tested, which are numbered 8 and 9 in the table, and were constructed as shown in Fig. 6. The rims were solid, of an I-section, and were made of a close-grained cast iron having a high tensile strength. Each wheel had 24 spokes of steel wire, 12 on each side of the central plane. A pair of spokes

*A paper read before the American Society of Mechanical Engineers.

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‡Engineering News, Dec. 1, 1898.

constituted a loop, fastened at each end to the rim with a thread and nut, and passing spirally around the hub in a groove cut for that purpose. By tightening up the nuts at the rim the wheel could be accurately centered and sufficient friction caused at the hub to prevent slipping.

The two wheels failed at precisely the same speed, 4,050 revs. per min., or a rim speed of 424 ft. per second. This would correspond to a centrifugal tension of nearly 18,000 lbs. per sq. in., and is probably the maximum speed attainable with a cast-iron rim. The rims usually broke through the holes where the spokes were fastened, and the spokes themselves broke at one or both ends, where threaded. The spokes had been adjusted to a uniform tension before the test by "tuning" them to the same pitch. This uniformity of tension, and the large number of spokes, must have prevented any serious bending of the rims, so that the latter failed by direct tension. The speed given is the highest attained in any of the experiments.

Wheels numbered 10, 11 and 12, had the usual flanged joints, located midway between the arms and fastened with four ⅝-in. bolts. The joints in wheel No. 10 were unsupported, while those in wheels Nos. 11 and 12, were strengthened by steel tie rods running from hub to joints and bolted at each end, as shown in Fig. 7. The net tensile strength of each tie rod was about 5,000 lbs. The two rods connected to each joint had then a combined tensile strength about two-thirds that of one arm. Wheel No. 10 burst at 1,570 revolutions per minute, a rim speed of 164 ft. per second, which is only about five-sixths of the speed usually attained by this class of wheel. The break was in the rim just beside the flange, and the low speed would indicate a poor quality of iron.

Wheels Nos. 11 and 12 broke at 2,100 and 2,200 revs. per min., respectively, or at an average rim speed of 225 ft. per second. Comparing these with wheel No. 10, as the three wheels were of the same iron and identical in every respect save the tie rods, we find an increase of from 34 to 40% in the bursting speed due to the use of the tie rods. This corresponds to an increase of nearly 100% in the strength of the joint. If the tie rods had been more carefully designed and constructed, a greater speed could have been attained. The ties broke through the bolt holes at one or both ends, the bolts remaining intact with but one exception.

Wheels Nos. 13 and 14 were of peculiar construction, as may be seen from Fig. 8. The rim of each was cast in one piece, while the hub and arms formed a spider, also in one casting. The arms were jointed to the internal flanges of the rim by ⅝-in. steel bolts, giving some degree of freedom. The object of this consfruction was twofold: (1) To relieve the bending moment at the junction of the arm and rim. (2) By concentrating more weight near the arms to stretch these latfer and thus relieve the bending moments in the rim midway between the arms.

These two wheels burst at 3,650 and 3,850 revs. per min., or an average rim speed of 392 ft. per second. Comparing these figures with those given for wheels Nos. 1 and 2, we find that the speeds are practically the same. There is no apparent advantage in the special construction just described over the ordinary method of casting the spokes and hub with the rim. Fig. 8 shows the appearance of wheel No. 13 after rupture. The arms all broke at the eye near the rim, the bolts not being injured. Only one web was fractured.

Wheels Nos. 15 and 16 were also of special construction, as seen in Fig. 9. The hub and arms were cast together as a spider and bolted to pads on the rim. The two joints in the rim came over arms, and the rim between the arms was reinforced by elliptic webs. The construction is a slight modification of that suggested by Mr. A. J. Frith, of this society, in a paper read in December, 1899. (Eng. News, Dec. 14, 1899.) Briefly, this construction is intended to stretch the arms more and bend the rim less than the common form.

These two wheels burst at 2,080 and 2,175 revs. per min., respectively, or an average rim speed of 223 ft. per second. Fig. 9 shows the manner of failure. The ends of the arms failed in several different ways: sometimes it was the screws that broke, sometimes the lugs on the arm, and sometimes the pad on the wheel. The rim usually broke at points midway between the arms. In wheel No. 16 the joints remained intact. It will thus be seen that Nos. 15 and 16 were of practically the same sfrength as Nos. 11 and 12, but only about one-third as strong as wheels with solid rims.

The conclusions of the previous paper are confirmed by these further experiments. For wheels of moderate size correctly proportioned, the solid rim is by far the safest form, and will require a speed of from 350 to 400 ft. per second to produce rupture. The stress due to bending is so small as to be negligible.

Jointing the arms at the rim and bracing the rim by internal webs have no important effect on the strength. Joints in the rims are the principal source of weakness, especially if located between the arms. Probably no joint can be made for a rim of solid cross-section which will be more than one-thrid as strong as the rim itself. Hollow rims will permit of a much more efficient joint, as has been shown by Mr. John Fritz in his paper, read at the meeting of this society in May, 1899. The joints in Mr. Fritz's wheel are practically as strong as the rest of the rim. This construction is hardly possible in wide-faced band wheels such as are used on most shop engines. Joints similar to those shown in Fig. 14 are probably the best that can be devised for this type of wheel. If joints are located midway between the arms they should be reinforced by tie rods leading to the hub.

The English wheels Nos. 8 and 9, show clearly the advantage of numerous arms on any type of wheel. Even if the rims were jointed, such wheels would prove their superiority to those with the ordinary arms in maintaining their shape at high speed.

Results of Running Small Cast-Iron Flywheels at Bursting Speed.

No. of wheel.	Rim: Diameter, ins.	Rim: Breadth, ins.	Rim: Depth, ins.	Rim: Area, sq. ins.	Arms: No.	Arms: Section area, sq. ins.	Weight of wheel, lbs.	Bursting speed: Revolutions per min.	Bursting speed: Feet per sec.	Centrifugal tension: Pounds per sq. in.	Centrifugal tension: Total on rim.
1	24	4.06	0.85	3.95	6	1.08	97.2	3,700	387	14,980	59,000
2	24	4.10	0.80	3.65	6	1.08	94.7	3,850	403	16,240	59,000
3	44	4.00	0.84	3.73	6	0.95	94.0	1,800	188.5	3,570	13,500
4	24	4.00	0.84	3.73	6	0.95	91.7	1,850	193.6	3,750	14,000
5	24	4.00	0.84	3.73	6	0.95	95.0	1,900	199	3,950	14,780
6	24	4.00	0.84	3.73	6	0.95	96.0	1,850	193.6	3,750	14,000
7	24	2.22	2.23	4.43	8	1.67	123.0	2,450	256.5	6,000	29,400
8	24	3.00	2.50	2.46	24	0.049	60.5	4,050	424	17,970	44,000
9	24	3.00	2.50	2.46	24	0.049	60.5	4,050	424	17,970	44,000
10	24	4.03	0.80	3.67	6	0.98	96.5	1,570	164	2,700	9,920
11	24	4.02	0.80	3.59	6	0.92	97.0	2,100	220	4,800	17,200
12	24	4.02	0.80	3.59	6	0.92	95.7	2,200	230	5,300	19,000
13	24	4.06	0.83	4.08	6	0.92	114.5	3,650	382	14,600	59,600
14	24	4.06	0.82	4.08	6	0.92	116.0	3,850	403	16,300	66,500
15	24	4.10	0.56	2.90	6	0.95	88.0	2,080	218	4,800	13,900
16	24	4.09	0.57	2.92	6	0.95	87.0	2,175	228	5,200	15,200

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig 8.

Fig. 9.

FIGS. 2 TO 9. VARIOUS WHEELS USED IN BURSTING SPEED TESTS.

CLEANING THE DISTRIBUTING RESERVOIRS OF THE WATER-WORKS OF BURLINGTON, VT.

By F. H. Crandall, C. E.*

The low service distributing reservoirs of the water-works of Burlington, Vt., two in number, are earthwork, partly in excavation and partly in embankment, each about 15 ft. in depth, one of 3,000,000 and the other of 4,000,000 gallons capacity.

The natural soil, a clayey hardpan, is relied upon to retain the water, and a lining of concrete, brick and granite enables the thorough cleaning of each basin. The bottom of each reservoir is of concrete, 3 ins. in thickness.

The slopes, 1½ to 1, for the lower two-thirds are covered with brick laid on edge in cement; for the upper third, on which the fluctuation of depth and the action of the ice takes place, with granite 8 ins. in thickness, laid on broken stone.

The city water is taken from Lake Champlain, about three miles from the city, and about a mile from the nearest shore, a rocky promontory. The intake is located about midway between surface and bottom, on a cleanly-washed reef, where, at low water, the depth is about 30 ft. As might be expected, water from such a source contains but little sediment. The accumulations of six months, however, amount to a perceptible coating of very fine silty matter. This coating is augmented by dust from the adjacent turnpike, and the leaves, pollen, and other matter spread by the winds upon the water. Such dust, insects, organic matter and other debris, as will remain on the surface and accumulate at or near the shore, is skimmed off from day to day before its presence can become an eyesore or annoyance.

Twice each year, in the spring and late fall, the basins are emptied and thoroughly scrubbed. The spring cleaning is usually delayed until after the so-called fishy taste is noted. The average daily consumption being only 750,000 gallons, it is possible, without seriously impairing the fire protective efficiency of the works, to do without either of the basins for a sufficient length of time to permit cleaning.

For cleaning, fire streams, under high service pressure (about 40 lbs.) have been tried. A 2½-in. fire hose was laid from a nearby hydrant into an empty basin, and the scouring effect of a ¾-in. stream tested. It was found sufficient to do considerable damage, when accidentally misdirected, to accomplish good results when properly applied to a wet surface; and to work most unsatisfactorily where the surface had become dry, or partially dry, before the scouring was attempted. The conclusion reached was that the water pressure method afforded no advantage, either in economy of time or money, over that of muscular pressure. Fire hose being expensive, and water in the high service at times scarce, the method gave place to that of following the water down with rattan brooms.

Working with push brooms on a raft submerged about 6 ins., it is possible to thoroughly scrub about 3½ ft. of slope. By attacking the surface with an abundance of water, before it has had a chance to dry, a uniformly thorough job is secured. A raft about 2 ft. in width, built on two cleats, one at either end, is kept off the slope about 1 ft., by having the cleats project towards the shore.

Additional facility for spreading water over the portion about to be scrubbed, is secured by sinking the raft a few inches. The raft is held in position by a man, standing on the bank opposite the middle of the raft, holding taut ropes made fast to each end. To preclude the possibility of the raft slipping from the slope, and permitting a scrubber to drop into the reservoir, between raft and slope, the ropes from either end of the raft are tied together at the right length, one first having been

*Superintendent Water-Works, Burlington, Vt.

passed through the straight way of a 1-in. "T" at the top of a 1-in. pipe post, the pointed end of which is driven into the ground at each tying-up place. As the water recedes the rope is lengthened.

A cleaning gang consists of one tender and two or more scrubbers, the number of the latter depending on the rapidity with which the water is being discharged from the reservoir. When continued scrubbing fails to produce the desired cleansing effect, an iron scraper is resorted to. Standing with one foot on the raft, and one above on the slope, an excellent opportunity is afforded for wielding a push broom.

To insure good results, however, there must be no doubt in the mind of the man behind the broom, as to the stability of the raft. When the bottom is reached, constant commotion and repeated rinsings are necessary. The wind, if in the right direction, toward the outlet, will do the work of several men.

At this stage of the work, one is reminded of the western farmer, who offered to sell a hotel man frogs by the carload, but on draining his frog pond was surprised to find less than a peck. Frogs are always present, no matter how recently or frequently the pond may have been cleaned. Frequently minnows are found, and occasionally a small perch.

THE MEXICAN TRIP OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.

(Editorial Correspondence.—Concluded from p. 439.)

My last letter, written on the train, ended with our approach to Monterey. The first section reached there at noon, four hours' behind the scheduled time, and the second section three hours' later, consequently our program for the day was somewhat curtailed. On the arrival of each section, a special train took the party to the Monterey plant of the American Smelting & Refining Co., which is said to be the only place in Mexico where fine gold and silver are produced. The Parkes and Moebius processes are used in the refining. The silver is electrically deposited in a granulated form on a moving belt, and samples of it, contained in small vials wired to a printed card were given to each visitor for a souvenir.

After a rather hurried visit to these works, the party was taken to the new iron and steel works of La Compania Fundidora de Fierro y Acero de Monterey. This is a large and thoroughly modern plant, now under construction, built under the supervision of William White, Jr., consulting engineer, of Pittsburg. It comprises a blast furnace 85 × 18 ft., of an estimated capacity of 400 tons per day, with a full equipment of Babcock & Wilcox boilers, fire-brick hot-blast stoves, inclined plane hoist, automatic charging apparatus, etc., and provision for three additional furnaces of the same size; also an open-hearth steel works, with three 40-ton furnaces, a blooming mill, a rail mill and a structural steel mill, and a large foundry with three cupolas and an air furnace, and a machine shop, both equipped with electric cranes and a full outfit of modern tools and appliances. The drawing herewith given is a ground plan of the works, the portion shown in full lines being either finished or rapidly approaching completion, and the dotted lines showing projected extensions. It is proposed to add a Bessemer steel plant to the works as soon as the market for steel products shall justify its erection. It is the intention to make in these works every shape of iron and steel casting, forging or structural steel that is used on a railway. No expense has been spared in the construction of these works, and there is said to be ample working capital available to insure their successful operation. The situation is an excellent one, a high level plateau, raised 40 ft. or more above an extensive meadow, which gives abundant room for slag dumping. Ample supplies of ore and coking coal for the works are said to be available at different points within 100 miles.

To the outsider the one doubtful point in regard to these works is the extent of the market for its products, but this should increase rapidly from year to year; and given plenty of capital, a good supply of patience and energetic management, there is every reason to believe that the works will be highly successful, and a most important addition to the industries of Mexico.

In the evening the visitors were entertained at a ball given in the Juarez Theatre, which was attended by the Governor of the State of Nueva Leon and his staff.

The next day a special train took the party a few miles out of town to visit the Diente and Zaragoza mines of the Monterey Lead Co. These mines are located in the sides of a precipitous canyon. From the mouths of two tunnels, high up the mountain side, aerial wire-rope tramways, one spanning 1,500 ft. and the other 1,800 ft., bring the ore down to the railway station. A steep inclined plane is being built to another mine close by. The chief features of this trip were the walks into the narrow gorge to view the magnificent rocky peaks by which it is surrounded, and the fine luncheon and speechmaking.

In the afternoon the train returned to the city and a professional session for reading and discussion of papers was held in the Governor's Palace.

The first paper was entitled "The Coal Fields of Las Esperanzas, Coahuila, Mexico," by Edwin Ludlow, of Baroteran, Mex., the manager of the mines. The coal in these mines is a soft bitmuminous coking coal of good quality. Analysis from commercial shipments of lump coal to the Guggenheim smelter at Monterey give: Moisture, 2.0; volatile matter, 20.5; fixed carbon, 67.7; ash, 9.8. The vein is very regular, 8 ft. in thickness, of which 6 ft. 10 ins. is coal and 14 ins. impurities. The present output is about 1,200 tons per day. The paper says:

These mines should be of great assistance to all steam or coke users in the Republic, especially in the northern part, as they will furnish a fuel not only cheaper than the imported article, but also having the very great advantage of being supplied in regular quantities as may be needed, thus enabling consumers to avoid the carrying of large stocks, as is now necessary when importations by vessels are depended upon.

The present output of about 1,200 tons per day is sold to railroads and steam users throughout the Republic, principally, however, in the northern part. In the southern end we meet a strong competition from West Virginia coal, coming by water to Tampico and Vera Cruz. The development that has been made on this property in the last two years should convince anyone examining the plant that the earlier statements that "there was no coal in Mexico" are not borne out; that there is enough good coal in sight to meet all reasonable demands of steam users; and that fuel for that purpose, and at a reasonable price, is no longer one of the difficult problems for a projected industrial enterprise to solve.

One of the most interesting parts of Mr. Ludlow's paper relates to the Mexican labor question. We quote a few extracts:

The labor problem has "stayed with us" ever since we began and will always be a hard one, where work requiring a large number of men is laid out in Mexico. We have tried all kinds of importations—American miners, negroes, Japanese, Chinese and Italians—and the present remnants of these experiments make up a truly cosmopolitan population.

A study of the different results in the same mine, from the various classes of miners, gives the following average in number of tons per day, loaded in pit-cars: American (good miners), 10; negroes (good miners), 8; Italian (fair miners), 6; Japanese (fair miners), 5; Mexican (green), 2; and Chinese, 4 tons per day.

As 90% of our labor is Mexican, it can easily be seen what a large population and what extensive openings are required to produce 2,000 tons per day.

The boys are our strong hope. They work better and more steadily than the men; and, growing up to a daily routine of occupation, they will make better workmen than their fathers, who come to the mines from the intermittent working life of the farm or ranch. There has been also a marked improvement in some of the men. Many who came here when work was first started, wearing blankets and sandals, now dress in good style, wearing shoes, often of American make; and the sale of American furniture and cooking stoves is constantly increasing.

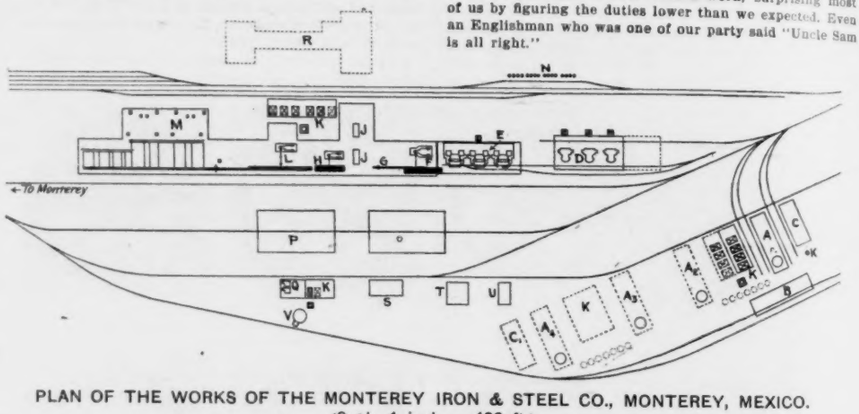
As hoisting engineers and helpers in the machine shop, we have found the natives good, where the work is laid out for them; but they lack initiative in taking hold in case of any breakdown; and it is necessary to keep American foremen in nearly every department. As mechanics, carpenters and blacksmiths, we are always able to get Mexicans competent to do any work laid out for them.

The whole problem of Mexico's future industrial and social development is brought before us by these words of Mr. Ludlow. What Mexico needs is first, a strong and just government, giving protection to life and to property, and this she has now had for many years under President Diaz. Second, the introduction of American capital and industrial management, of which we have seen so many notable examples. Third, the opening of coal mines and the building of steel works, which is now taking place, giving an opportunity for the Mexican peon class to become skilled laborers, as far as their natural ability will permit. Fourth, the education of the boys in industrious habits, and fifth, the awakening of the ambition of the laboring class to earn good wages, and to abandon blankets, sandals, and the miserable huts in which many of them live, and to adopt good clothing, shoes, furniture and cooking stoves, increasing their consuming power, and causing a demand for all the products of their improved methods of industry. Here in Mexico we find two civilizations, side by side, that of the 20th century, with its trolley cars, electric light, modern architecture, furniture and dress, and that of Central Asia, which is the same to-day as two thousand years ago, with its mud huts and blankets. Another generation in Mexico will see the disappearance of the latter and the complete establishment of the former.

In the evening there was a military band concert in the Place Zaragoza, and a dance in the beautiful ballroom of the Casino.

At 2 a. m. Wednesday we left Monterey, and the next morning found us at Baroteran, whence one of the trains took the whole party to the coal mines at Esperanzas, which were described in Mr. Ludlow's paper. We were taken into the mines on mule cars and then descended on foot into the workings. We also saw the long batteries of beehive coke ovens, 220 in number, in which a very good grade of 72-hour coke is made, the analysis, as made by the Guggenheim smelter being moisture, 0.5; volatile matter, 0.9; fixed carbon 83.9; ash, 14.7; sulphur, 0.06. Coke made from washed coal gave moisture, 0; volatile matter, 1.4; fixed carbon, 87.3; ash, 11.3. The coal washer has been recently introduced, and is designed to handle 1,200 tons per day. Better results than those shown by the above analysis are expected after more experience is gained in its operation.

In the afternoon our trains left Baroteran, and at 7 p. m. reached Eagle Pass, Texas. The customs officials kindly met us several miles before we crossed the border, and collected the duties on our drawn work, surprising most of us by figuring the duties lower than we expected. Even an Englishman who was one of our party said "Uncle Sam is all right."



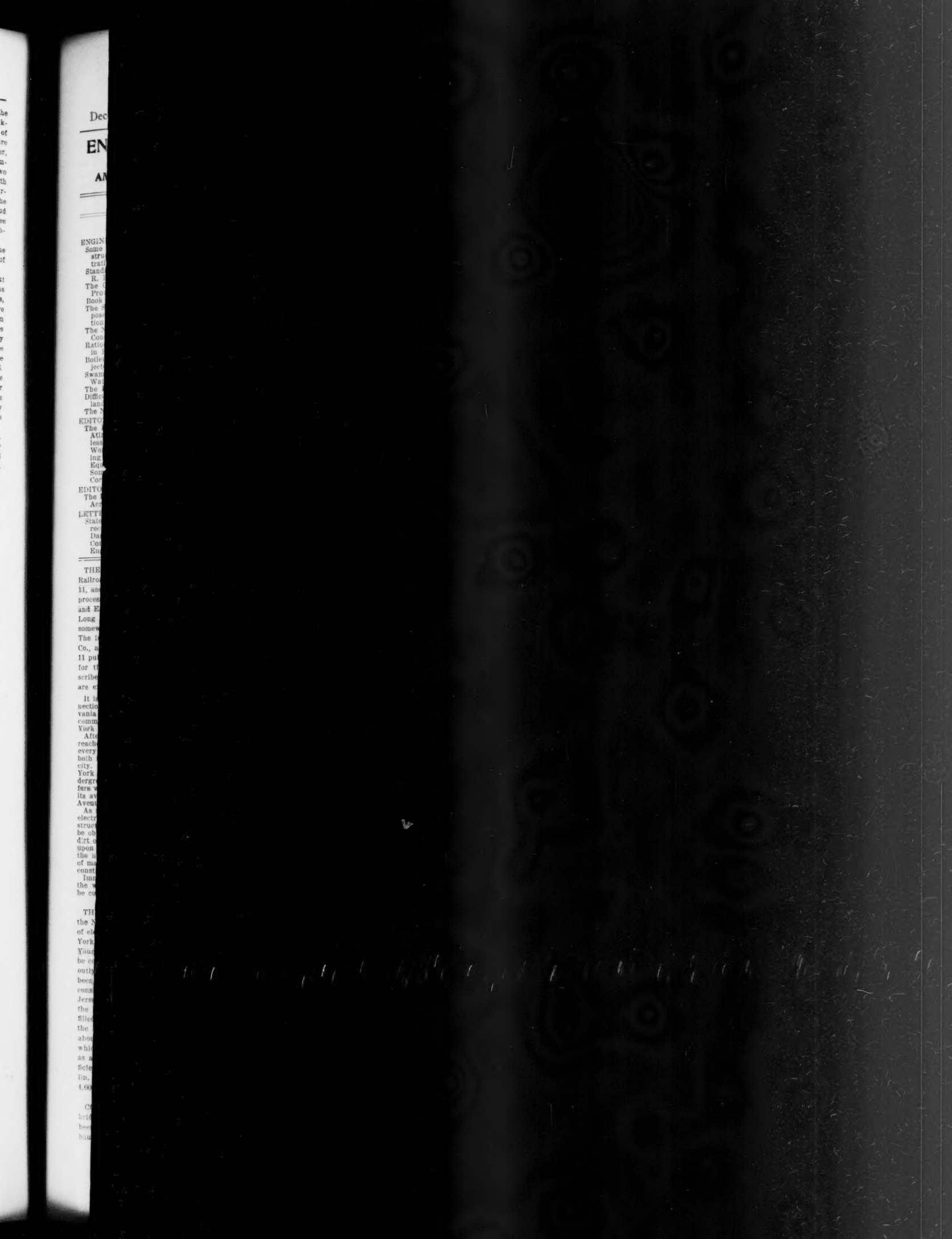
PLAN OF THE WORKS OF THE MONTEREY IRON & STEEL CO., MONTEREY, MEXICO.
(Scale 1 inch = 400 ft.)

DESCRIPTION.

A A2 A3 A4	Blast Furnaces.	H	Roughing Mill.	P	Machine Shop.
B	Stock House.	J J	Reheating Furnaces.	Q	Electric Power House.
C C1	Blowing Engine.	K K K	Boilers.	R	Plate Mill.
D	Open Hearth.	L	Finishing Mill.	S	Forge Shop.
E	Soaking Pits.	M	Finishing Dept.	T	Warehouse.
F	Blooming Mill.	N	Gas Producers.	U	Oil House.
G	Shear.	O	Foundry.	V	Standpipe.

We traveled all the following day and night through Texas and Louisiana, reaching New Orleans early in the morning of Friday, Nov. 29. On Thursday afternoon the second section was run a few miles off the main line to visit the oil fields at Beaumont, Texas, where we saw the forest of oil well rigs at that famous place, but the "gushers" had all been piped, and but little oil was running to waste.

On Friday we had the whole morning to visit New Orleans, and left at noon for Chicago. The most rapid run of our trip was now made, and we arrived in Chicago at 2 p.m. on Saturday, an hour ahead of our scheduled time. Here we dropped the second section of our train. The first section left Chicago at 6 p. m. and made a slow run to Pittsburg, losing five hours, and then a fast run, gaining half an hour on limited train time, to Jersey City, which we reached at 11 p. m.

A pleasant incident of the trip on Friday evening was the presentation of some pieces of fine old creole silverware, purchased in New Orleans, to Mr. Theodore Dwight, assisstant secretary of the Institute, who had planned and managed our whole excursion, and to Mr. E. W. Parker, who managed the second section.

We traveled nearly 9,000 miles, and reached New York without accident, and with a higher average of health than when we started on the trip a month ago. Our thanks are due especially to our President, Mr. E. E. Olcott, whose knowledge of Spanish, and whose wide acquaintance in Mexico proved of invaluable service to our party, to Mr. Dwight for his splendid management, and to the hundreds of Mexican officials, engineers, superintendents of works, etc., who were unbounded in their hospitality, and did everything that men could do to make this trip of the Institute the grandest it has ever taken. W. K.